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A Summary of Current Program 7/1/67

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and Preliminary Report of Progress

for 7/1/66 to 6/30/67

ANIMAL HUSBANDRY RESEARCH DIVISION

of the

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

and related work of the

STATE AGRICULTURAL EXPERIMENT STATIONS

This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1966 and June 30, 1967. It also includes a list of related publications of State Experiment Stations for the same period. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Animal Husbandry Research Division, Agricultural Research Service, U. S. Department of Agriculture, Agricultural Research Center, Beltsville, Maryland.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.

July 1, 1967

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INTRODUCTION

This Animal Husbandry Research Division progress report is written under a different format than those of past years. We have attempted to show our program of work and report of progress in the same problem oriented pattern as the Long Range Study. We have used as Areas of work the Research Problem Areas of the Long Range Study, rather than the class of livestock and discipline orientation of the past. Therefore, our research program shows what we are doing, both basic and applied, to solve the problems that face the livestock and poultry industry. Similarly, our progress reports show, by bits and pieces, how we are getting along in achieving our objectives. The result is a better picture of the current situation, and a clearer view of what still needs to be done. Under the new format it readily will be apparent what problems are receiving our major attention and which involve relatively little effort.

Research in livestock production will benefit the public through lower-cost animal products and an assured supply of high quality foods more suited to their needs. It assists individual farmers by lowering costs and increasing net income.

The mission of the Animal Husbandry Research Division is to conduct research which will reduce costs of animal production, provide the consumer with animal products of improved quality, and provide a fund of basic science information to draw upon in the future. More and more of the easy steps toward production efficiency are being solved. Now progress is more difficult because the problems are more complex. New basic information on the genetics, physiology and nutrition of livestock is needed. Our scientists are having to place increasing emphasis upon basic research and studying problems in depth.

The investigations of the Animal Husbandry Research Division are carried out by a staff of approximately 500 persons, of whom about 130 are included in the intramural SMY (scientist man-year) totals shown in our programs. The work is conducted at Beltsville and at field locations throughout the United States. Many of the projects are carried out in cooperation with State agricultural experiment stations, other divisions of ARS, other Federal agencies and non-Federal organizations.

It is frequently costly and unwise to make extensive program shifts until a promising and worthwhile research project is completed. Furthermore, most animal husbandry investigations are necessarily long term in nature. Consequently, it is easy to lose sight of the degree to which progress has been made in a yearly report such as this. A few of the more recent developments which have made marked contributions to industry and/or to public and industry research activities are mentioned briefly below.

Causative agent of Marek's disease identified as herpesvirus. The virus that causes acute avian leukosis or Marek's disease has been examined under the electron microscope and identified as a herpesvirus at East Lansing. The herpes group of viruses is quite different from the virus group causing lymphoid leukosis. The herpes virus group lacks an outer coat and is found largely in the nucleus of cells. Prior to this research finding, the causative agent of Marek's disease was unknown. (Area 211)

Marek's disease virus grown in tissue culture. The causative agent of acute leukosis or Marek's disease was grown for the first time in the laboratory. Scientists at the USDA Regional Poultry Research Laboratory were able to grow the virus in a tissue culture of duck embryo cells. Chickens injected with infected duck embryo cells came down with Marek's disease while those injected with uninfected cells did not. The fact that the virus was successfully grown in tissue culture is an important finding. Earlier it was necessary to propagate the agent in living poultry, a serious handicap in some research. (Area 211)

Cell count studies lead to a uniform and reliable method of abnormal milk control. Long-term studies on the concentration of body cells in milk have found significant application in the control of abnormal milk. Current and proposed control programs have been seriously limited by the lack of a standard assay method of defined precision. Techniques developed in the mastitis laboratory of the Dairy Cattle Research Branch for direct microscopic counting of body cells in milk and the statistical methodology developed for their evaluation are serving as the basis for a new standard method currently in preparation by a subcommittee of the National Mastitis Council. Adoption of the method will make possible for the first time nationwide comparability of results in abnormal milk testing. (Area 211)

Performance of swine fed diets containing pesticides. Investigations involving informal collaboration with the Entomology Research Division were conducted to measure the effects of dietary exposure to heptachlor, malathion, and DDT on growing-finishing swine and on reproductive performance of female swine. In addition to feeding four levels of heptachlor (0.014 to 2.8 ppm of the diet) and one level each of DDT (34 ppm) and malathion (150 ppm), one lot received heptachlor in the diet and was sprayed with malathion, and another lot was fed condemned milk produced by cows which received heptachlor contaminated hay. The pesticides used at the levels fed had no observable adverse effects on health, rate of gain, feed efficiency of pigs, or on reproductive performance of female swine fed the pesticides through three gestation cycles. Results of residue analyses by ERD indicate that heptachlor residues in swine decrease to below allowable tolerance levels if the animals are fed a "clean" diet for a long enough period of time after dietary exposure to low levels of heptachlor. (Area 213)

A brain substance found to control ovulation in chickens. Researchers have demonstrated the existence of an ovulating hormone releasing-factor and have identified it as a peptide. Injection of this purified brain extract resulted in ovulation in normal hens but not in hypophysectomized hens. This demonstrated that the releasing-factor acts directly on the pituitary gland and not on the ovary. This finding is a major step in the determination of how light and other environmental factors act to regulate ovulation and egg laying in chickens. Much indirect evidence suggests that certain nerve cells in the base of the hen's brain produce a substance involved in ovulation. On receipt of a light controlled signal, the releasing-factor is discharged from the nerve terminals into the blood stream and carried to the anterior pituitary gland where it causes release of ovulating hormone. (Area 310)

Factors affecting hybridization of chickens and turkeys. Recent studies on hybridization of chickens and turkeys have shown that (1) intraperitoneal injections of Beltsville Small White Turkey hens with a Dark Cornish Chicken semen-adjutant mixture, prior to artificial insemination by the same semen donor, can suppress the ability of their subsequent eggs to undergo hybrid embryonic development, and (2) that a long period of weekly inseminations of turkey hens with chicken semen will not necessarily produce long-lasting hybrid fertility. A hypothesis has been proposed to explain these results on the basis of turkey hens so treated having reacted by developing an immunity to antigens associated with the chicken semen. (Area 310)

Sterilization of boars with cadmium chloride. Mature boars were used to study the potential of cadmium chloride (CC) injections as a method to induce sterilization in boars. The injection of 100 or 200 mg. of CC induced sterilization. The boars remained sterile for at least five months. The treatment caused a 50% reduction in the weight of the testis and the accessory organs. In boars that received unilateral injections, the effects were restricted to the injected testis, the contralateral one remained unaffected. These data suggest that a single intratesticular injection of cadmium chloride can induce sterility in the boars. This method may provide an inexpensive and simple way to castrate boars chemically. It is simpler and reduced the stress normally associated with surgical castration. It also provides a way to obtain seminal fluid free of sperm cells which will help in identifying the biochemical components contributed to semen by the accessory organs. Further, it might be used in premarket weight boars that would be treated at a predetermined time before marketing. This would be an advantage since the endocrine balance of the boar favors nitrogen retention and enhances deposition of protein over that of the barrow. (Area 310)

Phospholipids and fatty acids of boar spermatozoa and seminal plasma. The phospholipid composition of boar spermatozoa and seminal plasma along with their component fatty acids were identified. Reports in this area on boar semen are lacking, though considerable work has been conducted on the

sperm lipids of other species. The necessity for these studies lies in the fact that basic knowledge is needed concerning the sperm cell in order to plan future experiments dealing with preservation at subfreezing temperatures.

Six phospholipids were quantitatively identified in the spermatozoa and seminal plasma. They were sphingomyelin, choline phosphatide, serine phosphatide, ethanolamine phosphatide, phosphatidic acid, and polyglycerol phosphatides. Lysolecithin was also found in the seminal plasma but not in the spermatozoa. Choline phosphatide constituted 42% of the spermatozoa phospholipid while comprising only 11% of the seminal plasma phospholipid. Sphingomyelin, however, comprised 34% of the seminal plasma phospholipid and only 15% of the spermatozoa phospholipid. The quantities of each phospholipid were tested on two frequencies of ejaculation, 4x/12 days and 12x/12 days. There was no significant change in either spermatozoa or seminal plasma phospholipid concentrations when the boars were subjected to the more frequent ejaculation.

Gas chromatography was utilized to determine the fatty acid composition of the spermatozoa phospholipids. Twenty-one acids were tentatively identified. Those fatty acids present in the greatest quantities were hexadecaenoic, docosapeuteuoic, and docosahexeuoic. (Area 310)

Cows reproduce successfully on high-urea diets. With the increasing demand for the use of natural protein sources in the diets of humans, the pressure for the use of nonprotein nitrogen by animals is great. We are studying the effect of feeding 2/3 of the total nitrogen in a poor quality 51% forage diet as either (1) soybean meal, (2) 1/2 soybean meal and 1/2 urea, or (3) urea on the growth and reproductive performance of heifers. There were no differences in gain, feed consumed or efficiency for the first 252 days. Diets had no significant effect on services per conception, length of gestation period, birth weight of calves and number of days from calving to first heat. (Area 311)

Temporary growth retardation does not permanently impair reproductive performance. The importance of adequate nutrition in markedly improving the reproductive performance of a beef heifer has long been recognized. However, differences of opinion still exist in regard to the best nutritional level for this process. In a growth study it has been shown that cycling heifers weighing 400 pounds can be fed at maintenance for at least 16 weeks and then if they are allowed a high level of feed and are gaining at a rapid rate for approximately 12 weeks, their reproductive performance will be normal and their economy of gain will be equal to heifers which were fed to gain at a continuous rate of .9 pounds per day over the same period. (Areas 310 and 311)

Linoleic acid requirements for reproduction. Linoleic acid was found to be essential for optimum egg production, egg size, and hatchability. Decreased yolk dry matter, percentage of yolk, lipid content, and arachidonic acid content may be contributing factors to low hatchability of linoleic acid deficient eggs. Also, the majority of embryos in such eggs were in an abnormal position in the egg at 22 days of incubation. One percent of linoleic acid was found to be adequate for egg production and hatchability, but more than 1% may be required for maximum egg size. (Areas 310 and 311)

Importance of ovulation rate and selection for it in ewes. The number of lambs born is highly dependent on ovulation rate. The rate at one estrus cycle showed a high relation to ovulation rate and number of embryos developing at a subsequent estrus cycle. Other results show that ovulation rate one year is associated with number of lambs born in other years. Now a laporatomy restraining device has been developed at Dubois which makes examination of reproductive organs in the ewe more efficient and less laborious. The method is rapid and accurate, and reduces traumatization, dehydration and bacterial contamination of the reproductive tract. This improved technique reduces adhesions to a negligible level and makes practical the selection of ewes on the basis of ovulation rate. These results from Dubois, Idaho, in cooperation with the Idaho Agricultural Experiment Station, have important selection and management implications in increasing lamb crops. (Area 310)

Thyroid material in diet lowers reproduction in mink. Feeding of "bullet trimmings," a packing house byproduct, to female mink in the spring caused reproductive failures due to resorption of the kits and poor milk production by the mothers. Levels of 7-1/2 percent and 15 percent of gullet trimmings or their equivalent as Tri-iodothyronine and sodium L-thyroxine gave poor reproductive performance. This byproduct should not be fed during the reproductive season. (Area 310)

A new assay for female sex hormones. A new method for assaying the female sex hormones, which control reproduction in all females, has been developed. As little as 25 trillionths of a gram of estrogen, placed into the vagina of young rats, can be detected by measuring the increase in vaginal glycogen. The glycogen increase is directly proportional to the amount of estrogen given. This new method, which is simpler and much more sensitive than existing methods, is now being used to detect estrogens in human and cattle urine and the blood of farm animals. (Area 310)

Soybean oil not recommended for finishing cattle. A series of feeding trials with finishing steers and heifers indicated that the inclusion of 5% soy oil in a finishing ration based on corn decreased average daily gains, decreased feed intake and appeared to increase the amount of feed required per pound of gain. The oil containing ration appeared to be less palatable based on feed intake and feed behavior observations. It was concluded that soy oil should not be added to all-grain rations based on corn. The differential did not appear to be as great when hay was included in the ration. (Area 311)

New nonprotein nitrogen sources for cattle prove promising. Urea, biuret, urea phosphate and uric acid were evaluated as sources of nonprotein nitrogen for cattle. Metabolism trial results indicated that the digestibility of dry matter and gross energy were significantly greater when uric acid was compared to biuret. Fiber digestibility was significantly less when steers were fed biuret compared to the other sources of nitrogen. Nitrogen retained by the steers, expressed as a percentage of intake, was 18, 17, 12 and 23 for urea, biuret, urea phosphate and uric acid, respectively. (Area 311)

Silage digestibility is increased by formic acid treatment. Under some circumstances forage crops cannot be wilted as recommended. Animal performance on silage from unwilted crops has generally been lower than on good hay because of a lower intake of digestible energy. Recent results showed that the energy in formic acid treated silage was 13% more digestible than in good hay and that digestible energy intakes on treated silages and hay were equal. Furthermore, daily gains in heifers were 11% greater on the silage. The combined effect of these two factors was a 25% increase in the productive energy of silage as compared to hay.

Formic acid has previously been used as a silage preservative but this is the first time that improvements in digestibility and utilization have been noted. More research is needed to determine optimum rates to apply for specific forages but the concept of increasing forage digestibility by this system has broad implications. Present costs would seem to be justified by the benefits obtained. (Area 311)

Silica as a factor in low feed value in grasses. Silica that is absorbed and metabolized by forage grasses has been found to be an exceedingly important factor in the reduction in digestibility of structural carbohydrates. In some species--e.g., reed canary grass, and possibly Coastal Bermudagrass and tall fescue--silica rivals lignin in importance. Metabolized silica is incorporated into cell walls.

Statistical studies show that the indigestibility of grasses unexplained by known factors (such as lignin content) is closely related to silica content. Silica interferes with the digestibility of cellulose and other grass components. For every additional unit of silica a grass contains, digestibility decreases three times.

Silica accumulation appears to be characteristic of some kinds of grasses. Plant breeders may be able to develop new breeds of grasses of higher nutritive value by selection of those that do not accumulate silica. (Area 311)

Depression of digestibility. It has recently been reported that the addition of increasing amounts of concentrates to the ration of heavily lactating dairy cows causes a depression in digestibility of the ration. From this observation it has been reasoned that more energy would be required to produce a pound of milk as the level of concentrate feeding

increased. In experiments conducted in the energy laboratory at Beltsville, the depression in digestibility was also observed as the level of concentrate feeding increased. However, the results also showed lower losses of energy in the form of methane and urine, which offset the lowered digestibility so that within the respective rations the same amount of digestible energy was required to produce a pound of milk regardless of the level of feeding. Thus, it is not necessary to increase the requirements for producing a pound of milk with increasing intake as had been proposed elsewhere. The practical value of the energy balance trials as conducted in the energy laboratory are apparent. (Area 311)

The response of swine selected for high and low fatness to a difference in protein intake. A comparison of 12 and 20% protein diets showed that there was a reduction in the proportion of carcass lean from 52% on the 20% protein diet to 46.8% on the 12% diet. The low fat lines of both the Duroc and Yorkshire breeds produced the greatest reduction in carcass lean while the dietary effect on the high fat lines was relatively small. The overall limits of carcass lean for the eight line-diet combinations ranged from 59.6% lean in the low fat Yorkshires fed a 20% protein diet down to 39.5% lean for the high fat Durocs on the 12% protein diet. This illustrates the wide range within which a combination of breeding and nutrition effects can influence the composition of the hog carcass. (Areas 311 and 409)

Low concentrate-high roughage feeding of dairy animals in India. PL 480 sponsored research at the National Dairy Research Institute, Karnal, India, shows that dairy heifers on a low concentrate-high roughage ration exhibit normal growth and reproduction. It was found that approximately 50% of the concentrate levels previously considered as necessary could be replaced by good quality home-grown fodders without affecting either the growth rate, blood chemistry, or physiological reactions. The protein requirement for nonlactating cows was maintained by feeding 10 to 11 kg. of green berseem. The energy requirements were maintained by feeding 2 to 3 kg. of oat straw daily. Milk yields, up to 10 kg. per cow daily, were maintained by feeding only green berseem. However, it was necessary to supplement nonleguminous fodders with concentrates at this and at higher levels of milk yield.

These results demonstrate that good home-grown roughages can largely replace the need for concentrate feeding to dairy cattle at Karnal, India, except for cows lactating considerably in excess of 10 kg. per day. (Area 311)

Crossbreeding beef cattle. Extensive studies at several locations show that heterosis from first crosses gives advantages of from 5 to 10 percent in pounds of calf weaned per cow bred as compared to the averages of the parental breeds bred straight. Using first cross cows as dams approximately doubles the advantage. Heterosis is expressed to the greatest degree in fertility, viability of calves and preweaning growth rate. In addition to its heterotic effect, crossing of breeds permits use of specific crosses with desired combinations of characters not present in any existing breed. (Area 313)

Genetic control of parthenogenesis in chickens. Parthenogenesis, defined as undifferentiated membrane formation in unfertilized eggs of chickens, has appeared to respond to selection and, therefore, to be under genetic control. However, the genetic mechanisms have not been previously described.

A single locus, autosomal recessive hypothesis for the control of this phenomenon was tested by F₂ and backcross methods. No test of differences in rate of occurrence among positive testing females was made. Deviations from the expected proportions of positive and negative testers were small and statistically insignificant. From these data, it seems that this trait is genetically controlled and the inheritance of occurrence is single locus, autosomal recessive. Incidence among positive testers seems to be influenced by modifying genes. (Area 313)

Range sheep production responds to selection. Preliminary information from a breeding and selection program involving a large range flock of sheep over the past eight years would indicate that the weaning weights in the groups of sheep designated to produce breeding ram replacements are now about 10 pounds heavier than a control group representing an average of all the other lambs in the operation. (Area 313)

Identification of two protein polymorphisms in sows' milk. Two distinct types of protein polymorphisms in both the whey and casein fraction of sow milk have been discovered. Both polymorphisms appear to be controlled by two codominant alleles. The casein polymorphism migrates in the same region as bovine β -casein and consists of two bands, designated as Cn₃^A and Cn₃^B. The whey protein polymorphism migrates in the same region as bovine β -lactoglobulin and consists of two bands, designated as Wh₁^A and Wh₁^B. Both A and B types of the whey protein have been crystallized. Amino acid analysis of the two fractions shows that they differ only in the content of alanine and valine.

Casein and whey protein types are determined by single pairs of genes making them convenient traits for genetic studies. Duroc and Yorkshire differ somewhat in the prevalence of whey types. About 95% of the Durocs studied showed evidence of carrying a gene for the A type, while only 25% of the Yorkshires appeared to carry the same gene. About 28% of the Durocs and 22% of the Yorkshires carried the A gene for casein. Further family studies are needed to substantiate the existence of the proposed genetic polymorphisms. (Area 313)

Improved USDA-DHIA sire evaluations. More accurate and complete USDA-DHIA sire evaluation procedures were put into effect in June 1967. These improvements were developed during recent research by the USDA and several State universities. Among the new procedures adopted were improved age adjustment factors that more properly account for differences due to seasons and geographical location; a method of adjusting summaries for nongenetic differences between bulls arising from the number of herds in which their progeny were located; number of lactations per daughter; and days in milk

of cows not allowed to complete a normal lactation. Revisions in electronic computer methods have also reduced delays in supplying the sire summaries to the dairy industry. (Area 313)

A new method of measuring eggshell strength. There has been a great need for a reliable, rapid method of measuring shell strength of eggs. Such a method has been developed and tested by the Agricultural Engineering Research Division and the Poultry Research Branch, utilizing electronic counting of emitted beta particles that are returned by a given area of the shell in a specified length of time.

Tests of the beta, backscatter method have shown very high correlations with shell strength as measured by resistance to impact. However, the backscatter method is many times more rapid and convenient and can be used commercially. In these tests, three five-second counts were sufficient to reveal the strength of individual eggshells; however, there is some indication that with improved testing procedures one five-second count may be sufficient. (Area 409)

AREA NO. 211. CONTROL OF DISEASES OF LIVESTOCK AND POULTRY

Problem. Infectious diseases represent the single greatest hazard to the production of an adequate and wholesome supply of animal protein. They are a constant threat to the livestock or poultry producer, who can be wiped out of business by a catastrophic disease outbreak. This hazard increases as the prevalence and severity of a disease increases. The total losses to the public from animal diseases will exceed \$2.6 billion annually by 1980, if continued at the present rates. Losses result from mortality, reduced productivity, cost of treatment or immunizations, cost of regulatory programs, and condemnations of meat at the slaughterhouse. Some diseases which cause losses in animals are also transmissible to man.

USDA AND COOPERATIVE PROGRAM

The Animal Husbandry Research Division's scientific effort in this area is limited to a few specific areas of concern. These involve the breeding, feeding and management practices that play a role in the control of livestock and poultry diseases and basic research on avian anatomy.

More specifically, metabolic disorders in beef cattle and sheep are being studied at College Station, Texas, using sheep as the experimental animal. Research on effectiveness of sanitation in reducing mastitis and evaluation of somatic cell counting in abnormal milk quality control is done at Beltsville, Maryland. Management methods to prevent reproductive diseases and other diseases in sheep are investigated at Dubois, Idaho, in cooperation with the Idaho State Experiment Station, the Idaho Department of Agriculture and the National Animal Disease Laboratory. Similar work on mink is done at Ithaca, New York, in cooperation with Cornell University.

The Animal Husbandry Research Division has the primary responsibility for research on the avian leukosis complex. This is a continuing program in virology, pathology, immunology, epizootiology and genetics on basic and applied studies on the neoplasms of the avian leukosis complex. Most of the studies are conducted at the Regional Poultry Research Laboratory, East Lansing, Michigan. Work is also done in cooperation with more than a dozen other Federal, State or commercial agencies located in several sections of the United States.

The primary objective of these studies is to develop a practical program for the prevention of losses due to the diseases of the avian leukosis complex. Most of the effort has been and currently is directed toward two approaches. The first is to develop a program to increase resistance of the chicken to avian leukosis. It has been found that the level of viral stimulated antibodies and certain yet undefined physiologic mechanisms are genetically controlled and have very important influences on resistance.

For significant progress in this approach it has become evident that basic studies must continue to be conducted on (1) mode of inheritance, (2) mechanism of gene expression, (3) interrelationships of resistance to different tumor viruses, avenues of exposure, and other genetically controlled traits, (4) dynamic interrelationships between infection, antibody and neoplasms, (5) ultrastructure, biochemistry and the molecular biology of the causative virus and infected cells, and (6) the mechanism of influence of the bursa of Fabricius on neoplasia.

The second approach is directed toward the prevention of infection and/or elimination of the disease. Avian leukosis is a contagious disease. The infectious virus is transmitted not only by direct contact with infected chickens, with infected environment, and with insect vectors, but also via the infected embryonating egg. The most important prerequisite for progress in the development of eradication measures is a simple but adequate method of detecting current or past infection. Only recently has notable progress been made on this aspect, and further simplification of procedures can be expected. Such fundamental epizootiological information as the extent and prevalence of infection, the modes of spread of infection, the importance of various vectors and reservoirs, the importance of various environmental factors and other concomitant diseases, and the influence of passive as well as active immunity must be obtained before a rational program of eradication can be developed.

Recent developments have demonstrated that there are at least two different families of viruses -- not one as formerly thought -- that cause similar types of leukosis. This emphasizes the magnitude of the problem that still faces us, but at the same time clarifies the problem so that studies can be planned with a much greater expectancy of significant results than heretofore.

Airsacculitis is a major cause of condemnation in poultry. Since Newcastle disease virus is a triggering mechanism of airsacculitis, a selection program for genetic resistance to Newcastle disease is in progress at Athens, Georgia.

The Federal scientific effort devoted to research on this problem area by the Animal Husbandry Research Division is 15.2 SMY distributed as follows: beef 0.4 SMY, dairy 1.7 SMY, poultry 12.2 SMY, sheep 0.8 SMY, and fur animals 0.1 SMY.

There are two grants involving Public Law 480 funds in foreign countries involving control of metabolic disorders in sheep. One grant is with the Hebrew University of Jerusalem on studies of the carbohydrate and fat economy of lactating sheep with particular reference to ketosis at the Hadassah Medical School and supported for three years (1965-68) by \$57,960 equivalent in Israeli pounds. The other grant is for a project on the effects of feeding and management on white muscle disease in lambs at the Ankara University, Ankara, Turkey, and is supported for five years (1963-68) by \$9,333 equivalent in Turkish lire.

Avian leukosis research contracts are in effect with Cornell University, University of Connecticut, University of Georgia, University of California, University of Arkansas and University of Massachusetts. In addition, cooperative agreements with at least seven universities or commercial concerns were in effect during the reporting period. Also cooperating in this area of research are the Animal Health Division and the Animal Disease and Parasite Research Division of the Agricultural Research Service. A PL 480 project has been initiated with the Institute for Biological Research, Ness-Ziona, Israel (four years 1966-70). The project is concerned with obtaining estimates of the incidence of avian lymphomatosis in Israel, the epizootiology of causative viruses and development of a rapid method of diagnosing the disease.

PROGRAM OF STATE EXPERIMENT STATIONS

The program of the State stations in this area is included in the Multiple Use Report of the Animal Disease and Parasite Research Division of the Agricultural Research Service.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Metabolic Disorders

1. Urinary calculi - beef and sheep. At College Station, Texas, restricting the activity of wether lambs did not affect the number of animals developing uroliths, but it did increase the time required for the stone to develop. Ammonium chloride, ammonium sulfate, potassium citrate and ammoniated phosphoric acid decreased the incidence of stone formation. The addition of ammonium chloride to a diet containing diethylstilbestrol and either oxytetracycline or chlortetracycline did not affect urinary excretion of the antibiotics. Replacement of 3% of the protein meal in a diet containing diethylstilbestrol with 0.5% ammonium chloride, 1.0% ammonium sulfate and 1.5% of a commercial ammoniated phosphoric acid preparation markedly reduced rate of gain and feed consumption. (03 30 028 and 03 33 010)

2. Urinary calculi in lambs. Mineral levels of Na, K, Ca, Mg and P that have been indicated as calculogenic and noncalculogenic, in previous work in Texas, were fed to two groups of lambs at Beltsville, Maryland. A third group was fed the calculogenic mineral levels, plus 1% sodium metasilicate. Twenty wethers were used for each diet. During the first 126 days the animals were group fed in pens bedded with sawdust; no clinical cases of calculi were observed. Eight animals were then slaughtered from each group; a number of small calculi were found in the bladder of one animal from the calculogenic group; no signs of calculi were observed in animals from the other treatments. The rest of the animals were put in individual pens with raised screen floors and continued on the treatments. After a subsequent 130 days, two clinical cases of calculi had been observed in lambs on the calculogenic diet and calculi were found in three additional lambs at slaughter. The bladder from an additional lamb appeared

to have been affected by calculi. No clinical cases were observed or calculi found at slaughter in animals from groups receiving the noncalculo-genic and silicate supplemental diets. (03 33 010)

3. Depraved appetites of sheep. Feeding of 0.23 kg. of alfalfa hay, grass hay or peanut hulls per animal, per day, has controlled wood chewing by ewes receiving a basal diet of alfalfa pellets at Beltsville, Maryland. The three types of roughage have been equally effective during the last two feeding seasons. No differences in weight gains of ewes, birth weight of lambs or number of lambs alive at one week of age can be ascribed to the dietary treatments. (03 33 009)

4. Control of epididymitis in rams. Out of a total of 290 mature rams at Dubois, Idaho, 65 were suspected of having the ram epididymitis organism (REO). Some of these rams showed palpable lesions and positive serum Complement Fixation (CF) test but no positive semen culture. Other rams had palpable lesions but no positive serum or semen test. Another group (13 head) exhibited no palpable lesions but did have REO isolated in the semen. This group was vaccinated with Ramadol for REO and after a four-week period 50% of these rams had palpable lesions. Another group of rams (18 head) had positive CF tests but it was not possible to get positive semen tests. The tissues on these rams were examined after slaughter. Results are not available to date. A management scheme where ram lambs (535 head) were maintained separate from mature rams during the first year indicates that isolating yearling from mature rams decreases the incidence of REO. Only four rams out of 535 showed palpable lesions and this observation has not been substantiated by serum and semen tests. (03 33 025)

5. Effects of ram epididymitis on fertility. Rams (14 head) showing ram epididymitis organism (REO) infection but showing good semen were compared with rams (15 head) showing no REO infections but with good semen at Dubois, Idaho. Percent of ewes lambing of ewes bred was 86.1 for REO infected rams and 90.2 for rams not showing REO infection. Percent of ewes having dead or immature lambs was 7.4 (REO rams) and 5.5 (non-REO rams). These differences were not significant. However, an important difference was found in percent of rams having good semen when REO infected rams were compared to rams not REO infected. Thirty-eight percent of the REO infected rams were rejected for breeding because of poor semen compared to 8% rejection for rams not infected by the REO. (03 33 025)

6. Ketosis in lactating sheep. Basic studies with lactating sheep, in relation to ketosis, have been continued in Israel. The data indicate that ketones may be derived from more than one source. A distinction between adipose and rumen derived ketones has been postulated. It also has been suggested that acetate and butyrate contribute to rumen derived ketones. (03 33 022)

7. White muscle disease in lambs. Administration of vitamin E to pregnant ewes in Turkey, did not prevent white muscle disease (WMD) in their lambs. Subcutaneous injection of lambs with a Turkish product

containing sodium selenite and vitamin E resulted in recovery of 99% of lambs affected with WMD. The combination of sodium selenite and vitamin E also was an effective prophylactic agent when administered to unaffected lambs from flocks affected with WMD. (03 33 024)

8. Study of wet-belly syndrome of mink. The wet-belly syndrome is being studied at Ithaca, New York. This syndrome which causes stained fur and unprime skin on the ventral area of mink pelts is considered to be the most important cause of loss of revenue to mink ranchers due to management or disease. The cause(s) of this problem is unknown. In September 1966, ten dark males showing the symptoms of wet-belly disease were obtained from Oregon State University. These mink were bred to 20 females from the Ithaca herd in order to study heredity of the disease and to obtain animals for investigation. In addition, ten wet-belly mink were autopsied and their reproductive and digestive organs compared grossly and histologically to those of normal mink. It was found that the testes of the wet-belly mink contained proportionally more interstitial tissue in relation to seminiferous tubules, that there was less spermatogenic activity and that the lumens of the tubules were less developed than the controls. (03 34 004)

B. Mastitis

1. Influences of environmental sanitation on the incidence of mastitis. A study is in progress designed to determine the effectiveness of strict sanitation in reducing the incidence of mastitis. Initially an attempt is being made to define conditions under which a high rate of natural infection can be induced in a small number of rigorously controlled cows by introducing a pathogen into their environment. Six cows have completed their first lactation in each of two controlled environment chambers and a second lactation study, comprising chiefly the same cows, is nearing completion. Exposure to massive contamination of the milking machine with Streptococcus agalactiae at each milking of each cow resulted in no infections during the first lactation and only sporadic infections during the second. Interposition of mechanical stress through timed overmilking has not potentiated udder infection by this organism nor has it been reflected in elevated somatic cell levels in the milk. Similarly negative results have followed the addition to the mechanical stress of controlled elevation of ambient temperature from 70 to 95° F. for six hours each day. Cultural studies support the concept that S. agalactiae does not colonize the external teat opening, and that repeated exposure to this pathogen does not have a cumulative effect on incidence of gland invasion. (03 31 044)

2. Direct microscopic somatic cell count in milk. In cooperation with several university laboratories, a revised procedure for cell counting is being evaluated in preparation for its recommendation for use in commercial and regulatory milk quality control. This method, developed at Beltsville, Maryland, substitutes the scanning of calibrated strips within strained milk films for the previously accepted individual field counting. A statistical model has been devised for direct microscopic cell counting which permits for the first time an accurate evaluation of the precision of

any given cell count, once the procedure for its determination is known. The combination of revised methodology and clarified interpretation offers the advantages of more rapid microscopic screening of milk samples and increased reliability of between-laboratory comparisons of results. An adaptation of this system to routine quality control is being developed to supply the technological basis for administration of local and national abnormal milk control programs. (03 31 044)

C. Avian Leukosis Complex

1. Development of optimal experimental chickens. Intensive inbreeding of four lines has continued with selection among sublines to maintain reproductive ability. One and probably two sublines appear to be homozygous at the histocompatibility loci. Skin grafting will be continued another year to confirm these results. The existence of several lines differing in susceptibility to the avian leukosis complex, each of which accepts skin grafts within the line, will be extremely valuable in basic studies of genetic mechanisms of resistance and the immunological aspects of tumor virus infection and induction of neoplasms. (03 29 026)

The first year of rearing some of the inbred lines in complete cage isolation to produce specific pathogen-free (SPF) chickens for critical experiments has pointed up some of the difficulties associated with this procedure. At the same time considerable progress has been made. A nucleus breeding stock of lines 6, 7 and 15I has been proven free of lymphoid leukosis, avian encephalomyelitis, Salmonella pullorum and S. gallinarum, infectious bronchitis and Newcastle disease, by tests for antibodies or infectious agents. Tests for avian adenoviruses and Marek's disease virus require further developmental work. (03 29 039)

2. Lymphoid leukosis. In vitro studies of the mechanism of resistance controlled by the single gene locus involved in resistance to subgroup A viruses indicate that the genetic block occurs at the step of cell penetration and virus uncoating. If resistant cells are infected in some way by the excluded virus, viral replication proceeds normally. This confirms the hypothesis that the block occurs only at the initial stage of infection. However, unless there is phenotypic mixing, it is particularly difficult to infect resistant cells because the exclusion of the virus by resistant cells is nearly absolute.

Results obtained with pedigreed progeny of our lines inoculated with subgroup C Rous sarcoma virus suggest that genetic resistance may be present in one of these lines. The existence of this third locus must be confirmed by more extensive experiments with this line. (03 29 027)

Further tests with testosterone showed that injection at one day of age is just as effective in preventing lymphoid leukosis as surgical removal of the bursa of Fabricius. The extent of bursal atrophy is directly related to the dose of testosterone injected and both are directly related to the suppression of the incidence of lymphoid leukosis. However, there was

also a direct relation between the dose of the hormone injected during the first week of life and the suppression of rate of egg production. Further work is directed toward obtaining the desired effect without a loss in egg production. (03 29 036)

Studies of the serologic relationship of viruses of the leukosis-sarcoma group have been completed for eight strains or pseudotypes. These are of subgroup A: BH-RSV(RAV-1), BH-RSV(AMV-1), SR-RSV-1, and BS-RSV; and of subgroup B: BH-RSV(RAV-2), BH-RSV(AMV-2), SR-RSV-2, and HA-RSV. The results show that there is complete antigenic distinctiveness between viruses of different subgroups. In some instances serums from chickens immunized with one virus also neutralized other viruses of the same subgroup and the frequency of these cross reactions increased with the period between immunization and serum collection. Studies of sera from commercial flocks showed a high incidence of subgroup A antibodies, and a moderate (13-28%) incidence of subgroup B antibodies. Subgroup A positive sera showed very little within-group specificity, but many of the sera reacted only with one subgroup B virus. (03 29 035)

One set of experiments was conducted to determine whether leukosis virus stocks are mixtures of unipotent viruses, each of which causes different types of tumors, or whether each virus was multipotent. Two viruses of the avian leukosis-sarcoma group, F₄₂ and AMV, were attached to RSV as helper viruses and then separated from the RSV and inoculated into susceptible chickens. The recipient chickens succumbed with a full spectrum of tumors indicating that, within the limits of the technique, the viruses are multipotent and each produces a spectrum of tumors. (03 29 025)

3. Marek's disease. Studies on biocharacterization and methods for in vivo assay have continued within the JM and GA isolates of Marek's disease (MD). These isolates have been propagated in line 7 chicks for 38 (JM) and 17 (GA) passages. JM has retained high pathogenicity with lesions principally in the nerves and gonad. The pathogenicity of GA has varied from passage to passage and lesions were predominantly in the viscera. Some of the GA-induced tumors were apparently the result of direct transplantation of inoculum cells. Chicks of source 15 x 7 (progeny of line 15 sires and line 7 dams) were found to be optimal for in vivo assay of these isolates since they had high susceptibility and most control lots were free of lesions. The assay procedure has been simplified by (a) reducing the number of chicks per experimental lot from 12-15 to 8, (b) reducing the experimental period from 10 to 6 weeks, and (c) for some experiments, using gross instead of microscopic lesions as the response criteria.

A new isolate of MD, namely CR 64, was obtained and passed serially 13 times in chickens. This agent produced many visceral tumors and was similar in many respects to the GA strain of MD. During the last four passages an attempt was made to determine whether RIF positive viruses had any effect on the pathogenicity of this strain of MD. There was no evidence of enhancement or interference. (03 29 081)

Several types of cultured chicken embryo cells were found to maintain infectivity of the JM strain for several weeks. Bone marrow cells were optimal for this purpose although positive results were also obtained with spleen, kidney, liver and lung cultures. Whole embryo fibroblasts and heart cells were apparently refractory. High levels of infectivity were present in bone marrow cultures as early as four days after inoculation with whole blood and did not increase detectably over many weeks in culture. However, positive evidence is lacking that the virus replicates in this culture system.

Whole embryo-derived cells from other avian species were also studied. Turkey and quail embryo cell monolayers showed no morphologic changes, but about 25% of the JM donor bloods induced a morphological alteration or cytopathic effect (CPE) in duck embryo cells at 19-25 days after infection. Supernatant fluids, and on occasion cell extracts, from morphologically altered duck cell monolayers induced similar alterations in fresh duck embryo cell monolayers. Filtrates failed to induce the change, suggesting transmission of the CPE by a cell associated agent. All duck embryo cells with CPE induced by supernatant fluids or cell extract were infectious for chickens while cells without CPE were not. In each of five trials where CPE occurred in duck embryo cells, after being seeded with fresh JM donor blood or cell containing fluids from monolayers with CPE, the altered cultures have induced MD in chickens. Other seeded, but unaltered cells (eight trials) and all nonseeded control cells (six trials) failed to induce MD in chickens, strongly suggesting a cause-and-effect relationship between CPE in duck embryo cells and MD in chickens. (03 29 081)

Extensive electron microscopy studies of tumors, different tissues, different components of blood, and oral washings of birds with MD failed to show with consistency any morphologic entity which could be considered a candidate for the etiologic agent of MD. However, nuclear abnormalities indicating the presence of a virus were observed in the tumor cells obtained from 90% of Marek's disease cases. A herpesvirus has been consistently found in the duck embryo fibroblast cultures seeded with JM infectious blood which develop CPE. These cultures invariably reproduced Marek's disease when inoculated into susceptible day-old chicks. A perfect correlation was obtained between the presence of this herpesvirus, cytopathic effect in cell cultures and reproduction of MD in birds. (03 29 075)

In studies on natural sources of infection it was found that in trials with JM, infectivity was present at one or more test intervals in the oral washings, fecal extracts, and droppings, while with GA, the virus was present in oral washings on one occasion but was not detected in fecal extracts or droppings. Air from chickens inoculated with both isolates was consistently infectious. Infectious litter and droppings from JM-inoculated chickens stored at room temperature retained this infectivity through at least 16 weeks in two trials and eight weeks in five of eight trials. Although litter mites were present in some of these stored samples, the evidence suggests that their presence was not necessary for survival of infectivity. Chicks placed in uncleaned cages which previously contained

JM-inoculated chicks develop a high incidence of MD. Application of disinfectants of several types (phenol, iodine, chlorides, quarternary ammonium, formalin) according to manufacturers' recommendations of dosage and application rate, has failed to consistently reduce or eliminate the MD-inducing potential of such contaminated cages. (03 29 079)

A differential diagnosis of lymphoid leukosis and the visceral form of Marek's disease, especially in mature birds, is a vexing problem for most diagnosticians. Preliminary studies have shown that when Methyl Green Pyronin Stain or Shorr's Stain is applied to smears of tumor tissue, differential features become more apparent, thus reducing the probability of error in arriving at a correct diagnosis. (03 29 077)

4. Studies under contract

a. Contract 12-14-100-8877(44) - University of Arkansas. These studies have resulted in some elucidation of the nature of the skin lesions of birds that are condemned for "skin leukosis." There was much variation in the nature and severity of the lesions. Some were compatible with what has been described as occurring in Marek's disease, whereas others should be classified as inflammatory. The latter contain, in addition to lymphocytes, many mononuclear macrophages (R-E cells), plasma cells, and heterophils. Some microscopic skin lesions were produced experimentally. (03 29 029)

b. Contract 12-14-100-8893(44) - University of California. These studies have suggested the possibility that a hemagglutinin may be involved in Marek's disease and that occurrence of infection may be detected by a hemagglutination test. It is apparent, however, that much more correlative data must be obtained before any conclusions can be drawn. (03 29 030)

c. Contract 12-14-100-8143(44) - Cornell University. These studies have shown a remarkable effect of progeny selection on the rapid development of lines of Leghorns very resistant or very susceptible to Marek's disease. By the use of the procedure of inoculating progeny with the JM strain of MD and holding them to eight weeks, selections were made so that in two generations Dr. Cole was able to separate a resistant line, JM-N, with an MD mortality of 12.9%, and a susceptible line, JM-P, with an MD mortality of 90.7% from an original population that had an MD mortality of 51.1%. This demonstrates that when adequate exposure of the progeny is employed and a high selection pressure is maintained, rapid advance to the desired goal can be expected. (03 29 028)

d. Contract 12-14-100-8288(44) - University of Connecticut. These studies have shown that MD agent (CONN-A isolate) propagates in chick embryo fibroblast cultures and produces a characteristic CPE. Such cultures can also be identified by fluorescent staining and by the agar gel precipitin test. However, these tests need further refinement and their value for the in vitro assay of MD agent has yet to be evaluated. Results of the fluorescent antibody reaction on bone marrow samples obtained from

inoculated and control chicks have correlated fairly well with the inoculation status of these chicks. Infectivity has been demonstrated in a pellet obtained from frozen and thawed blood by differential centrifugation and which presumably does not contain intact cells. (03 29 031)

e. Contract 12-14-100-7781(44) - University of Georgia. These studies have detailed many biocharacteristics of isolate GA and, notably, have shown consistent potency in plasma following centrifugation in excess of 8000 x gravity. A randombred broiler chicken known as Athens-Canadian has been identified as unusually susceptible to the GA isolate and should facilitate studies on MD in meat-type strains.

Considerable effort has been made to evaluate the role of coccidiosis on Marek's disease. Since coccidial infection failed to produce MD when given alone or to potentiate MD when given with isolate GA, it was concluded that coccidiosis was not a major influencing factor on the incidence of MD. (03 29 032)

D. Genetic Control of Newcastle Disease

One to three embryo tests were made in eggs produced by a total of 129 matings of "Newcastle Disease virus (NDV) resistant" and 112 matings of "NDV susceptible" Athens Randombred stock of the F₃ generation in order to determine the matings for production of the F₄ generation. To test the efficacy of selection thus far, chicks of five different hatches were tested at two weeks of age by an L.D.50 aerosol challenge of NDV. In all tests, survival at the twelfth day following exposure was greater in the resistant line. The mean 12-day survival values for the five tests were 9.15% for susceptible line and 18.54% for the resistant line.

The chicks of the F₄ generation were weighed at four and eight weeks of age. In each of the two hatches and at both ages, the susceptible line was significantly heavier than the resistant line. In addition, there was a significant sex X line interaction and summarization of the mean weights indicated that there was a greater difference between the females than males of the two lines. This research was conducted in cooperation with the Animal Disease and Parasite Research Division. (03 29 042)

E. Avian Anatomy

The research writing and illustrations for volume 1, "Avian Anatomy, Integument," have been completed. Excluding the bibliography, there are 2,474 typed pages of manuscript, divided into ten chapters and two appendices. There are 418 original illustrations.

This is a research study and not a compilation of data from the literature. A number of significant discoveries have come from these investigations on the histology of the avian skin and its derivatives. The essential processes of cornification have been established for the avian skin, a subject that has been controversial for many years for mammalian skin.

The spaces between the cells of the transitional layer (the layer next to the corneum) accumulate stainable material that has been named the inter-cellular laminae. These move outward along with the cells and become the laminae of the horny layer of skin, beak, claws and scales. The cells of the transitional layer are vacuolated and contain some granules between the vacuoles.

The nature of these were not known for some time, but sections cut parallel to the surface of the skin demonstrated that the granules were the cut ends of long, curved keratin fibrils. They are clustered in concentric whorls, maintaining continuity as they passed through the cytoplasm of several adjacent cells. They arise in the intermediate layer and extend to the horny layer. There still remained the problem of the vacuoles. The discovery of their significance came later when working on the histology of the oil gland.

When sections were made of the gland a few days posthatching, a close resemblance was noted in the cell structure of oil gland epidermis with the epidermis of specialized regions, such as the sulci between scales, the corner of the mouth and the cuticle overhanging the claw. In the oil gland these vacuolar spaces contained secretion material. The obvious question is: Do vacuolar spaces in intermediate cells of all of the epidermis likewise contain a secretion similar to that produced by the oil gland? Frozen sections treated with an oil stain on samples taken from interdigital web, scales on the ventral surface of the toes, developing down feathers of the gland nipple, follicles of flight feathers, comb, wattles, rictus and skin of the thigh showed in every case that the cells of the epidermis contained lipoid secretion granules which were carried into the corneum. The only exception was the cells producing those parts of the feathers that project beyond the collar.

It was concluded that the statement often repeated for 100 years, namely that birds, unlike mammals, only have one sebaceous gland in the skin, is incorrect. The evidence now indicates that the entire avian epidermis is a sebaceous-secreting organ and that the oil gland is merely a specialized organ having the same function. The gland may be used to oil the feathers but the skin oils itself. It may help to explain why species of birds that lack oil glands, such as some parrots, some pigeons, some woodpeckers, and others, can maintain their plumage in a healthy condition.

Other questions arise: is the whole skin, comb, wattles, etc. involved in vitamin D synthesis? Is it significant that in feather follicles which have a low amount of secretion, most of the secretion that is present borders the follicular cavity? It is these surfaces that slide apart in feather release. Would organoleptic studies show that chicken skin has, to a slight degree, the same flavor found in the cooked oil gland?

Detailed studies in gross and microscopic anatomy often open doors to important problems not previously suspected. (03 29 037)

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AREA NO. 212. CONTROL OF INTERNAL PARASITES OF LIVESTOCK AND POULTRY

Problem. Internal parasites, such as various kinds of worms, flukes, and coccidia cause losses in all parts of the country and in all seasons. In general, warmth, moisture, and shade favor parasites. About 300 kinds are of economic importance in the United States and will cause losses estimated at \$650 million annually by 1980 at present rates. Severe infestations of parasites may cause heavy direct losses to the livestock producer, but internal parasites generally are unseen, their effects are not apparent, and the loss to the public from inefficient production is hidden. Losses include mortality, reduced yield, condemnation of meat, feed wastage and cost of drugs. Even for the parasites that have been the subject of considerable research, treatment as control measures are far from adequate.

USDA AND COOPERATIVE PROGRAM

The only USDA program in this area is that conducted by biochemists and animal husbandmen involving management studies to reduce losses from internal parasites of sheep at Beltsville, Maryland, in cooperation with the Animal Disease and Parasite Research Division.

The Federal scientific effort devoted to research in this area totals 0.1 SMY for sheep.

PROGRAM OF STATE EXPERIMENT STATIONS

The program of the State stations in this area is included in the Multiple Use Report of the Animal Disease and Parasite Research Division of the Agricultural Research Service.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Management of Sheep on Pasture in Relation to Parasitism

Experimental work was started at Beltsville, Maryland, on May 10, 1967, to study the carryover of internal parasites affecting sheep, from one season to another on pastures and pasture forages. The experimental pastures were grazed by sheep during the months from June through December of 1966. Average packed red cell volumes, on July 19, 1967, were 35.2% and 35.0%, respectively, for lambs on pasture and for control lambs in drylot. No H. contortus eggs were found in fecal samples from either group on same date. Nematodirus spp. eggs per g. of feces were 64 and 41, respectively, for the experimental and control groups. Ostertogia spp. eggs per g. of feces were eight and six, respectively. (03 33 016)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None

AREA NO. 213. PROTECT LIVESTOCK AND POULTRY FROM TOXIC CHEMICALS,
POISONS AND OTHER HAZARDS

Problem. Livestock and poultry may suffer losses in productivity from atmospheric pollutants and pesticide residues remaining on crops used for animal food. Poisonous plants can cause heavy losses, particularly when pasture or range feed supplies are short or at seasons of the year when these plants are not discriminated against by the grazing animal. Predators cause heavy damages to sheep and turkeys.

USDA AND COOPERATIVE PROGRAM

A. Beef Cattle

Research is concerned with the effect of pesticides and other chemicals on the physiology of growing and reproducing beef cattle at Beltsville, Maryland.

B. Sheep and Fur Animals

This is a continuing program conducted by biochemists, nutritionists, physiologists and animal husbandmen to determine the effects of pesticides on sheep and fur animals and to prevent or reduce losses from these. The research is conducted at Beltsville, Maryland, and Ithaca, New York.

The total Federal effort in this area is 1.6 SMY distributed as follows: beef cattle 0.6 SMY intramural; sheep 0.5 SMY intramural; and fur animals 0.5 SMY intramural.

PROGRAM OF STATE EXPERIMENT STATIONS

The program of the State stations in this area is included in the Multiple Use Report of the Animal Disease and Parasite Research Division of the Agricultural Research Service.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Beef Cattle

At Beltsville, DDT in the feed did not affect ruminal fermentation, EKG and respiratory patterns or blood pressure indicating that this chemical does not impair animal productivity at the levels it is apt to be encountered. (03 30 016 2)

Although mechanism of action of diethylstilbestrol in promoting growth remains unknown, it has been determined that one of its effects is to decrease plasma concentration of urea, threonine, valine, lysine, histidine, tryptophan and arginine while increasing the concentration of glutamic acid. (03 30 032)

The effects of systemic organic phosphates (Ruelene, CO-Ral) on fertility and calf abnormalities do not appear to be extensive or consistent even when minimum toxic doses are applied. However, one cow treated with the minimum toxic level of Ruelene at 40 days gestation did deliver a calf with its rectum not connected to its anus. (03 30 039 4)

Steers showed no grazing preferences when grazing coastal bermudagrass treated with MCA-6000 or untreated. The MCA-600 residues reached concentrations of 80 ppm on a dry matter basis. (03 30 016 1)

B. Sheep and Fur Animals

1. Effects of pesticides on sheep. Experiments were initiated at Beltsville, Maryland, in late 1966 to study the effect of methoxychlor and malathion on reproduction of sheep. Five groups, containing 12 ewes each, are compared. One group received pellets made from alfalfa not exposed to insecticides. Methoxychlor and malathion at 2 X and 10 X the tolerance levels for alfalfa are added to pelleted alfalfa for the test diets. All ewes were hand-mated during December 1966 and January 1967. Number of ewes lambing on the control, low methoxychlor, high methoxychlor, low malathion and high malathion diets, were 83.3, 91.7, 83.3, 100 and 100%, respectively. Number of lambs per ewe lambing were 1.7, 1.2, 1.3, 1.3 and 1.3, respectively. Percents of lambs alive at one week of age of those born were 94.1, 76.9, 92.3, 93.8 and 56.2, respectively. Two lambs from the high malathion groups were abnormal. Red cell acetylcholinesterase in blood of the ewes averaged 0.159 pH/1 hr. at the start. On July 17, 1967, the level was 0.048 for the high malathion group, 0.146 for the low malathion group and averaged 0.186 for the control and methoxychlor groups. (03 33 020)

2. Effect of DDT on reproductive performance and growth of mink. During the past several years there have been clinical cases of reproduction failure in mink which may implicate Great Lakes fish. At the same time the fish have been found to contain DDT and analogs. Since in many cases these fish represent from 20% to 50% of the mink diet, it was believed necessary to investigate the effects of feeding DDT upon the reproductive performance and growth of mink. In January 1966 at Ithaca, New York, 30 female and 15 male mink, and 20 female and 8 male rats were assigned to each of four levels of DDT (0, 5, 10 and 100 ppm) in the regular diet supplied daily. Various organs (brain, fat, liver, testes, ovary) were taken monthly from similar animals so that storage and withdrawal studies could be conducted on the rate of buildup as well as the rate of disappearance of DDT. Another group of mink (40 female and 20 male) was

added to the study later. These mink received perch scraps or alewife, caught in the area of Green Bay, Wisconsin. This study is to be conducted through three generations of mink and four generations of rats. Results to date (one and one-half generations of mink and three generations of rats) do not demonstrate any differences that can be attributed to the effects of added levels of DDT in the diets. (03 34 005)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None

AREA NO. 214. PROTECT ANIMALS FROM HARMFUL EFFECTS OF AIR POLLUTION

Problem. Fluorides are known to cause a serious condition known as fluorosis in cattle. Laboratory experiments with animals show that certain irritants common in polluted air can increase susceptibility to respiratory infection and increase mortality.

USDA AND COOPERATIVE PROGRAM

Animal Husbandry has no current program in this area.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State stations in this area totals 2.0 SMY.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

None

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None

AREA NO. 310. REPRODUCTIVE PERFORMANCE OF LIVESTOCK AND POULTRY

Problem. Brood animals fail to come in heat, fail to conceive, abort with embryonic deaths, have stillbirths or lose their offspring in postnatal deaths. Poultrymen have no way of ensuring that all eggs incubated are fertile, nor of hatching all those which are fertile. Attainment of optimum reproductive efficiency could decrease the cost of producing our annual crop of calves, pigs, lambs, chicks, and poults by \$1.7 billion. For example, it costs \$80 a year to keep a beef cow. Maintenance of the 10.4 million beef cows that will fail to raise a calf in 1980 at current rates of reproduction would cost the public \$832 million. Similarly, dairying production costs would be increased by \$482 million, poultry production by \$155 million, hog production by \$143 million and lamb production by \$82 million.

USDA AND COOPERATIVE PROGRAM

A. Beef Cattle

Studies include research on (1) relation of nutritional levels to reproductive function, (2) genetic effects, particularly heterosis, on reproductive efficiency and viability of newborn calves, (3) causes of calf losses, (4) hormonal control of the estrual cycle, and (5) artificial production of multiple ovulations and twinning.

Research on various aspects of the reproduction problem is carried on at Beltsville, Maryland, six Federally-owned field stations each operated cooperatively with the State experiment station of the State in which located, and cooperatively with eleven other State experiment stations through three regional beef cattle breeding projects. A contract with the Nebraska Agricultural Experiment Station is included.

The Federal scientific effort on reproduction of beef cattle totals 5.1 SMY intramural and .4 SMY extramural.

B. Dairy Cattle

Research in this area is directed toward (1) methods of achieving sex control, (2) the endocrine basis for reproductive failures in farm animals, (3) effects of intrauterine devices on reproductive function in farm animals, (4) physiological bases for variation in fertilization success and embryo survival that may be associated with lowered fertility, and (5) comparative studies of "repeat breeders" and normal cows and heifers. Much of the research is basic and involves the use of sheep and other animals as experimental models.

This research is conducted at Beltsville, Maryland, at Madison, Wisconsin, in cooperation with the State station, and at Beit Dagan, Israel, under a PL 480 project.

The Federal scientific effort totals 4.2 SMY intramural and 0.4 SMY extramural.

C. Poultry

Emphasis is on the basic aspects of the physiology of avian reproduction. Research includes neural-ovarian relationships controlling ovulation and oviposition, parthenogenesis and fertility in avian eggs and homograft reaction and immunological tolerance in birds. In addition to physiologists, the work draws upon geneticists and poultry husbandmen.

This research is conducted at Beltsville, Maryland, and cooperation currently is maintained with members of the Farm Electrification Branch, AERD; Inspection Branch, Poultry Division, C&MS; the National Institutes of Health; and Pennsylvania State University. A PL 480 project is in progress at the National and University Institute of Agriculture, Rehovoth, Israel, on the effectiveness of selection and various artificial insemination techniques in increasing the fertility of chickens inseminated with turkey semen. Another PL 480 project at Hebrew University, Rehovoth, Israel, is a study of the bacteriological problems involved in artificial insemination of hens.

The Federal scientific effort in this area totals 4.6 SMY intramural.

D. Sheep and Fur Animals

This is a continuing program conducted by physiologists and animal husbandmen on basic and applied studies of physiology of reproduction of sheep. Factors influencing mating behavior, estrus, ovulation and embryonic development in ewes and mating behavior and fertility of rams are directed toward a more complete understanding of the reproductive processes in sheep. Studies of synchronization of estrus, induction of ovulation and estrus and pregnancy diagnosis are conducted to develop more control over the reproductive processes. Basic studies are conducted on the physiology of reproduction of fur animals.

The program is carried on at Dubois, Idaho, in cooperation with the Idaho and Utah Agricultural Experiment Stations, and with private ranchers, and at Beltsville, Maryland, on sheep and goats. Research on reproduction of fur animals is conducted at Madison, Wisconsin, in cooperation with the Wisconsin Agricultural Experiment Station and at Ithaca, New York, in cooperation with Cornell University. There is one grant of PL 480 funds in a foreign country involving studies on physiology of reproduction. A project on artificial insemination of sheep at the Volcani Institute of

Agricultural Research, Rehovoth, Israel, is supported for four years (1967-71) by \$175,824 equivalent in Israeli pounds.

The Federal scientific effort devoted to research in this area totals 2.8 SMY intramural and 0.1 SMY extramural for sheep and 0.1 SMY intramural for fur animals.

E. Swine

This is a continuing program conducted by physiologists and biochemists on basic and applied problems in physiology of reproduction. The research effort at Beltsville, Maryland, includes studies designed to improve the reproductive efficiency of males and females.

Cooperative studies on female reproduction at Missouri, Nebraska and North Carolina, which are part of the Regional Swine Breeding Laboratory, are included. Two PL 480 projects are under way with the Volcani Institute of Agricultural Research, Rehovoth, Israel, each for five years (1963-68), as follows: The Separation of Young and Old Spermatozoa supported by 237,310 Israeli pounds or approximately \$79,103.66; and Factors Acting in Long-Term Storage of Sperm in Vivo supported by 250,420 Israeli pounds or approximately \$84,474.

The Federal scientific effort in this area totals 1.7 SMY intramural and 0.1 SMY extramural.

F. Broadly Based

This program is mainly that of the Hormone Physiology Pioneering Research Laboratory. Its work involves physiological and biochemical characterization of reproductive tissues, estrogenic content of blood and urine of cattle and humans, antifertility effects of mechanical devices in the rat uterus, secretion of anterior pituitary hormones and ovulation in small ruminants, and water transport through animal membranes.

The research is conducted at Beltsville, Maryland, and under three PL 480 projects. A PL 480 project on the secretion of anterior pituitary hormones and ovulation in small ruminants is supported for four years (1966-70) by \$46,522 equivalent in Polish zlotys at the Polish Academy of Sciences, Jablonna. At Hebrew University, Jerusalem, is a study of water transport through animal membranes, including the influence of the pH and the ionic composition of the bathing fluids on the effect of vasopressin. It is supported for three years with a total of \$49,767 equivalent in Israeli pounds. A PL 480 project has been initiated at Panjab University in Chandigarh, India, on the synthesis of steroids containing a nitrogen atom which are related to estrogens, progesterone, androgens and other steroidal hormones. The project duration is four years (1967-71) with a total of \$23,473 equivalent in Indian rupees.

The Federal scientific effort in this program totals 3.0 SMY intramural.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State stations in this area totals 165.4 SMY which are distributed as follows: beef 25.3, dairy 47.8, poultry 32.9, sheep and other animals 25.7, swine 21.1, and cross species 12.6.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Beef Cattle

1. Nutrition and reproduction. Fifteen sets of identical and fifteen sets of fraternal twins are being individually fed either a high or low energy ration from 210 days of age until they have weaned three calves or are five years of age in an experiment in progress designed to evaluate genetic environmental influences and their interaction on cow performance and characteristics of their progeny. Age at first estrus was 22 days later for the heifers allowed the low energy diet; conception was 12 days later on the average and they required .33 more artificial services per conception. The data indicate that heifers fed a low level of energy gained in muscle and skeletal growth while they were nursing their calves while those fed the high level gained in muscle, skeletal growth and fat composition during the same period. The low level fed twins have produced less milk with a lower butterfat content than the high level fed twins. However, there has been no difference between mean birth and weaning weights of calves from the two groups of cows. This is apparently due to the fact that calves from the low level cows have consumed more feed prior to weaning than those out of the high level fed twins. During the first postpartum interval, the time to first estrus was not significantly different for the two groups. The conception date was 12 days earlier for the low level fed cows and services required per conception were .49 less. Cases of prolapse have been numerous among the fat cows while only one has occurred in the low level fed group. (03 30 026)

Another experiment is in progress to study reproductive physiology of the postpartum beef cow. Preliminary data indicate the interval from calving to first estrus is longer in cows suckling calves than in nonsuckled cows; however, to date among the cows that were bred at the first estrus postpartum, the conception rate has been higher for the suckled cows. (03 30 014)

Under Florida pasture conditions injection of 6,000,000 units of vitamin A twice yearly to mature cows showed no beneficial effects on reproductive rate or preweaning calf performance. (03 30 001)

At Front Royal, Virginia, vitamin A injections of cows late in gestation appeared to have a beneficial effect on calf survival. Injections of calves at birth had no apparent effect. (03 30 019)

At Miles City, Montana, Hereford and Angus heifers were wintered on range plus hay with a portion of each breed receiving a grain supplement. Winter weight gains averaged about 58 lb. for those receiving grain vs. 12 lb. for those on range forage and hay only. Beginning April 1, all heifers were fed grain on range to July 20, when they were put in drylot and artificially inseminated. The winter grain feeding resulted in 93% reaching puberty by July 20 as compared to 71% for those not receiving grain. Over both treatments Angus heifers had reached puberty by July 20 in 93% of the cases, while 76% of Hereford heifers had reached puberty. Ninety-two percent of the heifers receiving grain during the winter were pregnant as compared to 88% for those not fed grain. This work indicates the importance of winter feed level if yearling heifers are to be successfully bred to calve at near two years of age. (03 30 008)

At Fort Reno, Oklahoma, seven calf crops have been weaned in an experiment on levels of winter supplementation on native range for heifers entering the breeding herd and for the same heifers as brood cows. The treatments were: Low - no gain first winter as a heifer, 20% weight loss each winter thereafter; Moderate - 0.5 lb. daily gain first winter, 10% weight loss each subsequent winter; High - 1.0 lb. daily gain first winter, weight loss of less than 10% each winter thereafter; and Very High - self fed a 50% concentrate ration each winter. One-half of these cows were switched to the moderate level after the third winter.

The most marked sustained influence of the low level of wintering appears to be reflected in average calving date. The weight change pattern exhibited by the moderate level appears to be consistent with both productivity and economy of wintering. The weight change characteristic of this level was a gain of 97 lb. the first winter as weaner calves with subsequent winter weight losses of approximately 10-15% from fall weight including calving loss. Differences in cow survival resulting from level of wintering are not conclusive at this point but the trend favors the moderate level. Development and maintenance of the beef females at a very high level reduced productivity below that observed for the more moderate levels. The results obtained by switching cows from a very high to moderate level indicate that the damage to milk producing ability occurs early in life and is not corrected by lower levels after the third winter. Percent-age calf crop was, however, improved by this treatment.

The data presented for the individual yearly calf crops indicate that rather than select a level of wintering for the lifetime of the cow, consideration should be given to the life cycle feeding approach in which higher levels are used during growth and development of the female followed by lower levels after the cow has reached maturity, since the major influence of the various levels on cow productivity occurs during the first three calf crops. (03 30 031)

2. Genetic effects on reproduction. Results of a number of experiments are showing a favorable effect of heterosis on calf crop percentage born,

calf survival or both. More detailed results are given under Problem Area 313, "Livestock and Poultry Management Systems - Breeds and Breeding Systems."

3. Causes of calf losses. At Miles City, Montana, 910 parturitions were scored for difficulty and attempts were made to ascertain the cause of death for the 38 calves dying. Classifying by age of cow, 45.6% of two year old heifers, 22.2% of three year olds and only 3% of older cows experienced parturition difficulty requiring assistance at calving. Of the 38 calves lost, 11 had congenital skeletal or visceral abnormalities of unknown etiology, 17 were associated with difficult parturition, and ten died due to miscellaneous causes. (03 30 008)

4. Induction of multiple ovulation and twinning. At Miles City, Montana, results show that both pregnant mare serum and low doses of follicle stimulating hormone hold promise for induction of multiple ovulations and fertility. However, embryo survival to 35 days of pregnancy was low. (03 30 008)

At Fort Reno, Oklahoma, females synchronized with an orally active progesterone and treated with pregnant mare serum and human chorionic hormone ovulated more than a normal number of ova and in several cases, multiple births of normal calves ensued. (03 30 006)

This is considered a promising area for further research.

B. Dairy Cattle

1. Sperm cell separation. Studies are continuing on the sedimentation of sperm cells of bulls and rabbits in columns containing egg yolk media. It has been claimed that sperm with X chromosomes fall faster than those containing Y. This claim was based on the finding, in rabbits, that sperm from the bottom of the columns produced more females than males while the reverse was true of sperm from the tops of the columns. Media of various compositions were tested. Results from 110 sedimentation column experiments failed to indicate that sperm could be separated into two groups. However, there is variation in the rate of fall of individual sperm. At the end of most sedimentation experiments sperm were found in all portions of the column. Preliminary weight studies yield the rather surprising result of approximately the same average sperm head weights from both the top and the bottom of the column. Studies are continuing to obtain more data on this point. Tail as well as head weights will be considered. Sperm suspended in yolk media have been centrifuged in a sucrose density gradient which yields two density zones containing most of the sperm. Sperm not mixed with the yolk medium are not separated in the gradient but go to the bottom of the tube. It appears that the yolk affects the density of the sperm cells. Studies indicate that it is the lighter yolk material which affects the density of the sperm.

This study shows the complex nature of separating sperm cells for eventual sex control. (03 31 063)

2. Endocrine basis for reproductive failures in farm animals

a. Detrimental effect of injected hydrocortisone on embryonic survival in sheep. Further study was made of a previous indication that hydrocortisone reduced fertility in sheep. In three experiments, hydrocortisone acetate (HCA) was injected intramuscularly for four successive days beginning on the first day of estrus. In another experiment, injections were begun about three days before the onset of estrus and continued through estrus. The levels of HCA used were 25, 75, 200 and 225 mg. per day. HCA had no effect on fertilization, but it significantly reduced embryonic survival in two experiments conducted during late summer and early autumn. It had virtually no effect on fertility in two experiments conducted during the winter months. Injections of L-thyroxine (0.06 mg./day) did not overcome the antifertility effect of HCA, and had no effect by itself on embryonic survival. Results suggest possible involvement of adrenal hyperactivity as a factor in lowered fertility under some environmental conditions. (03 31 060)

b. Luteolytic effect of induced uterine infection in ewes. Inflammation was induced in the uterine lumen or in the broad ligament on the day following estrus. A uterine horn adjacent to an ovary containing an ovulation point was ligated at each end and injected either with 0.5 ml. of sterile saline solution or with 0.5 ml. of a suspension of Escherichia coli containing 8×10^9 cells/ml. In other ewes, the broad ligament at the base of the mesovarium suspending an ovary with an ovulation point was injected in three sites either with a total of 1.5 ml. sterile saline solution or with 1.5 ml. of an E. coli suspension containing 8×10^9 cells/ml. Each injection site in the broad ligament was ligated as the needle was withdrawn to prevent drainage of the saline or inoculum. Six days after treatment, the ewes were killed and corpora lutea weighed. The treatments and average weight of a corpus luteum on the treated side were saline in utero (seven ewes) 513 mg.; E. coli in utero (seven ewes) 94 mg.; saline in broad ligament (five ewes) 494 mg.; E. coli in broad ligament (eight ewes) 528 mg. Induced infection in the uterine lumen activated mechanisms that inhibited corpus luteum development ($P < .01$); inflammation in the broad ligament did not. (03 31 060)

c. Effect of sheep endometrium on luteal steroidogenesis. Twenty mature ewes were autopsied in groups of four when two animals were on day eight and the other two on day 14 of the estrus cycle. One ewe at each stage of the cycle served either as the endometrium or corpus luteum (CL) donor. Luteal slices (0.3 mm. thick) from ewes at each stage of the cycle were divided into four aliquots of 100-125 mg.: (a) unincubated control, (b) incubated in 3 ml. of Krebs Ringer bicarbonate (KRB) with 200 mg. percent glucose, (c) incubated with slices of day eight, or (d) with slices of day 14 endometrium. Initial concentrations of progesterone in

CL did not differ between day eight and day 14. Incubation alone stimulated de novo synthesis of progesterone similarly in day eight and day 14 luteal tissue, and incubation of endometrium with luteal tissue resulted in a further significant increase in steroidogenesis over all treatment groups. It is believed that CL regression at the end of an infertile estrus cycle is mediated by the endometrium. Since day 14 endometrium did not affect CL function differently than did day eight endometrium, the evidence was derived from this experiment for a direct detrimental effect of the endometrium on CL function. (03 31 060)

d. Estrogen suppression of ovine luteal function. Five ewes were injected with 750 μ g of estradiol 17 β in corn oil on day 12 and day 13 of the estrus cycle. Control ewes were injected with oil. All animals were autopsied on day 14. Corpora lutea were weighed and sliced to a thickness of 0.3 mm. Luteal slices from each ewe were divided into three aliquots: (a) unincubated control, (b) incubated in 2.95 ml. of oxygenated Krebs Ringer bicarbonate solution containing 6 mg. glucose for 1.5 hours at 37.5° C, (c) incubated in similar solution with 300 μ g of pregnenolone added. Corpora lutea in estradiol-treated ewes were smaller in size than those of control animals ($P < .05$), and luteal progesterone content and concentration were reduced ($P < .01$). Incubation alone stimulated de novo progesterone synthesis by luteal slices from both control and treated ewes, but the increase in synthesis was significantly less by luteal slices from treated ewes. Addition of pregnenolone to the incubation media overcame the suppressive effect of estrogen treatment on progesterone synthesis. Results indicate that estradiol, acting directly or indirectly on the CL, can suppress luteal function near the time in the estrus cycle that the CL ordinarily regresses. (03 31 060)

e. Effect of LH on luteal function in the rabbit. Mature female rabbits were given a single intravenous injection either of luteinizing hormone (LH) or saline solution on day nine of pseudopregnancy. LH and saline treated groups were autopsied at 1/2, 24 or 48 hours postinjection. Corpora lutea from LH-treated animals decreased in size and progesterone content and concentration decreased progressively over the three time intervals. LH caused an initial increase in luteal content and concentration of Δ^4 -pregnene-20 α -ol-3-one, followed by a decrease. Results indicate pronounced effects of LH on luteal function, and suggest possible means by which this pituitary hormone causes CL regression. (03 31 060)

3. Effects of intrauterine devices on reproductive function in farm animals

a. Disappearance and breakage of sperm in the sheep uterus.

Plastic spirals 6 cm. long and 8 mm. O.D. were inserted by surgery into one uterine horn. Other ewes were sham-operated and some ewes of each group were bilaterally ovariectomized. About eight weeks later, fresh undiluted ram semen was injected into ligated segments of both horns. Sperm injected per horn averaged 143 million. Five hours later, ewes were killed, uteri

flushed and sperm counted and observed for separation of heads and tails. Over all sheep, either in estrus, in the luteal phase of the estrus cycle, or after ovariectomy, average percentages of sperm recovered and average percentages of recovered sperm still intact were: 12 control ewes, 57% recovered, 84% intact (both horns); 30 ewes, spiral horn, 23% and 41%; nonspiral horn, 55% and 72%, respectively. Recovery rates were lower and breakage rates were higher in spiral horns than in contralateral non-spiral horns of the same ewes or in uteri of control ewes.

With other estrus ewes, percentages were five ewes, spiral horn, 23% recovered, 49% intact; three ewes, spiral removed before semen injection, 35% and 20%; six ewes, spiral removed and uterus flushed with saline, 65% and 20%; six nonspiral ewes, uterus flushed, 80% and 84%; four spiral ewes, uterus excised and incubated in body cavity, 87% and 90%; four spiral ewes, uterus excised and incubated in oxygenated bath, 67% and 90%, respectively. Flushing the uterus after removing the spiral increased sperm recovery, probably by removing leukocytes, but did not decrease sperm breakage. Excising the uterus increased sperm recovery and almost eliminated sperm breakage. Results indicate that plastic devices in the uterus activate mechanisms that cause sperm breakage and sperm disappearance. (03 31 060)

b. Effect of intrauterine devices on endometrial mucopolysaccharides in the cow. Plastic spirals were inserted into one or both uterine horns of Holstein dairy cows. Twenty-one cows were slaughtered three days postestrus, after the spirals had been in utero for 13 to 131 days. Hexosamine and uronic acid concentrations in the endometrium, determined chemically, were nearly doubled in the spiral areas, indicating accumulation of mucopolysaccharides (MPS). The effect was localized to the area of the spiral. Acid MPS were fractionated into hyaluronic acid, chondroitin sulfates and heparin monosulfate, and heparin prior to uronic acid determinations; each fraction increased similarly in the spiral areas. Increased MPS concentrations were also found in the spiral area of three cows 67-75 days pregnant in which the fetus and the spiral were in opposite horns. MPS concentrations in nine "nonspiral" cows were similar to those in nonspiral areas of "spiral" cows. Results indicate a marked effect of intrauterine devices on endometrial ground substance in the cow. (03 31 060)

c. Endometrial mucopolysaccharides in the ewe. Sixty ewes were laparotomized and plastic spirals (125 x 7 mm.) were inserted into one uterine horn of 36. Six spiral ewes plus six others were bilaterally ovariectomized. Eight weeks later, the ewes were sacrificed; cycling ewes were in estrus (day 0) or day three or eight postestrus. Inter-caruncular strips of endometrium were excised and hydrolysed in HCl; hexosamine concentrations were determined colorimetrically as a measure of mucopolysaccharide content. In control ewes, hexosamine concentrations were highest in estrus ewes, reduced slightly in three and eight day luteal phase ewes, and reduced markedly in ovariectomized ewes.

In "spiral" ewes, the effect of the spiral depended upon the endocrine state of the ewe. In estrus ewes, hexosamine concentrations were similar in uteri of control ewes and in spiral horns, but were reduced in the horn contralateral to the spiral ($P < .01$). In both three-day and eight-day ewes, concentrations were higher ($P < .01$) in spiral horns than in non-spiral horns of the same ewes or in horns of control ewes. Spirals did not affect hexosamine concentrations significantly in ovariectomized ewes. Results indicated a hormonally-influenced effect of intrauterine devices upon endometrial mucopolysaccharides.

In a similar study with rabbits, endometrial mucopolysaccharides were significantly lower ($P < .01$) in estrus and pseudopregnant rabbits with plastic spirals in the uterus than in control rabbits. Thus the effect of intrauterine devices on endometrial mucopolysaccharides differs among animal species. (03 31 060)

d. Spontaneous motility of sheep myometrium. Myometrium was studied from ewes of the following endocrine states: estrus (E), luteal-phase (L), ovariectomized (O) and ovariectomized ewes treated for five days with 500 μ g. estradiol/day (OE), 10 mg. progesterone/day (OP) or a combination of 500 μ g. estradiol and 10 mg. progesterone/day (OEP). Immediately following slaughter, 25 x 5 mm. strips of myometrium were excised and placed in oxygenated Krebs Ringer bicarbonate solution in a tissue-organ bath at 38.5° C. One end of the strip was fixed and the other end was tied to an isotonic writing lever. The amplitude (height in mm.) and frequency of contractions (contractions/min.) were recorded after equilibration for 30 minutes. Mean amplitude was greater in E ewes (16.6 mm.) than in ewes of each of the other experimental groups ($P < .05$). Mean amplitudes did not vary significantly among other groups (range 5.1 to 0.6 mm.). Frequency of contractions were: OEP 6.20, OE 5.18, E 4.43, O 3.27, OP 2.22, L 0.65. Frequencies were greater in OEP and OE ewes than in O, OP, or L ewes ($P < .05$). Frequencies were greater in E ewes than in OP or L ewes ($P < .05$), and were greater in O ewes than L ewes ($P < .05$). Results suggest that uterine motility in the ewe is regulated by ovarian hormones. (03 31 060)

e. Effect of intrauterine devices on motility of sheep myometrium. A plastic spiral was inserted surgically into the center of one uterine horn of each of 18 ewes (spiral ewes); both ovaries were removed from six of the ewes. Eighteen other ewes, six of which were ovariectomized, served as controls. Of the intact ewes, six spiral and six control ewes were killed during a subsequent estrus, and six of each kind were killed during the luteal phase of a following cycle. After slaughter, 5 x 25 mm. longitudinal strips were excised from the uterine horns, and motility was determined isotonicly by recording muscle contractions on a kymograph drum. Motility was measured by amplitude of contractions (height in mm.) and frequency of contractions (contractions/min.). Amplitudes of contractions (mm.) of myometrial strips from control ewes and from nonspiral and spiral horns from spiral ewes were: estrus ewes 21.29, 30.43 and 35.04;

luteal 1.36, 1.83 and 4.62; ovariectomized 9.04, 8.46 and 23.12. Amplitudes of contractions were significantly greater for spiral horns than for non-spiral horns of the same ewes or for uteri of control ewes ($P < 0.01$ for each comparison). Frequency of contractions was not significantly altered by the spiral. Results indicated that a spiral in the uterine lumen caused increased uterine motility. Results did not support the possibility that failure of sperm transport and ovum fertilization, which is caused by a spiral in the ewe, could be due to decreased uterine motility. (03 31 060)

f. Attempts to overcome the antifertility effect of intrauterine plastic devices in the ewe. A foreign body placed in one uterine horn of the ewe inhibits sperm transport and ovum fertilization on both sides of the reproductive tract. A plastic spiral was inserted surgically into one uterine horn of each of 44 ewes and the ovary on that side was removed; thus, ovulation always occurred opposite to the spiral so that possible physical interference with sperm transport was not a factor in the results. At the time of mating, two weeks to three months post-surgery, sham-operated and "spiral" control ewes were injected with saline; other "spiral" ewes were injected with estradiol, epinephrine, oxytocin, oxytocin and acetylcholine or oxytocin, acetylcholine and physostigmine. None of these compounds that affect uterine motility overcame the antifertilization effect of the spiral; each of eight ova from control ewes was fertilized, three of 12 ova from spiral control ewes were fertilized, and one of 40 ova from spiral treated ewes was fertilized. (03 31 060)

4. Physiological bases for variations in fertilization success and embryo survival that may be associated with lowered fertility

a. Effect of exogenous progesterone on corpora lutea in unilaterally hysterectomized heifers. The uterine horn contralateral to the ovary with the corpus luteum (CL) was removed at day 3 of an estrus cycle in 25 Holstein heifers. At a subsequent estrus (day 1) the ovary with the largest follicle was determined per rectum. Within groups of heifers with the follicle in the ovary ipsilateral to the retained horn and those with the follicle in the ovary contralateral to the retained horn, alternate heifers were assigned to progesterone treatment (100 mg. per day, SCI, days 1-10). Ten intact heifers were also assigned. Side of ovulation was verified by palpation and at autopsy on day 15. Average CL weights (gm.) and numbers of heifers were: intact, no progesterone, 4.98(5); intact, progesterone, 3.54(5); ipsilateral (CL in ovary on same side as retained horn), no progesterone, 3.98(7); ipsilateral, progesterone, 3.18(6); contralateral (CL in ovary opposite to retained horn), no progesterone, 3.80(6); and contralateral, progesterone, 3.54(6). Neither main effects nor interaction were significant. The effect of similar progesterone treatment on estrus cycle length was studied in ten additional heifers while intact and later after unilateral hysterectomy. Average estrus cycle lengths (days) and numbers of heifers were: intact, no progesterone, 20.8(10); intact, progesterone, 16.4(10); intact, no progesterone (for comparison with estrus cycles following surgery) 20.9(10);

ipsilateral, progesterone, 17.0(9); and contralateral, progesterone, > 31.8 (six of eight not in estrus before 35 days). Estrus cycle lengths were shorter ($P < .005$) in progesterone treated heifers when they were intact or ipsilateral but not when contralateral. (03 31 037)

b. Effects of exogenous progesterone and hysterectomy on development of corpora lutea induced in anestrus ewes. Exogenous progesterone depresses the weight of CL induced (beef pituitary extract) in anestrus ewes when the progesterone (25 mg. per day) is injected for six days prior to ovulation. The effect of hysterectomy on this action of progesterone was studied in 39 ewes assigned to four treatment groups: (1) intact, no progesterone; (2) intact, progesterone; (3) hysterectomized, no progesterone; (4) hysterectomized, progesterone. Average CL weight and number of ewes ovulating were 222.6(9), 54.6(8), 386.0(6) and 394.3(7) for the four groups, respectively. Progesterone treatment depressed CL weight ($P < .05$) and hysterectomy increased it ($P < .005$). However, the presence of an interaction ($P < .05$) indicates the effect of progesterone was different in intact and hysterectomized ewes. (03 31 037)

c. Ovulation, corpora lutea development and pituitary LH activity in rabbits with intrauterine devices. Sixty-eight oestrus New Zealand white rabbits were used in four experiments to study the pituitary LH content, ovulation time and corpus luteum development in the presence of intrauterine devices (IUD) fitted in both horns. The results indicate that the IUD-fitted animals ovulate later and their pituitary LH content following mating is higher than in sham-operated controls. Also the IUD animals have lighter weight and lesser luteinized corpora lutea compared to their sham-operated controls at 24 hours postmating. (03 31 037)

d. Some carry-over effects of pregnancy on the postpartum ovarian function in the cow. Observations on 206 calving intervals of 136 Holstein cows were studied to determine a possible influence of the CL or the uterine horn of previous pregnancy on the site of the first ovulation following parturition. The frequency with which the CL of first ovulation, postpartum, occurred in the same ovary as carried the CL of pregnancy was significantly less ($P < .005$) than the expected frequency based on the total number of ovulations in the right and left ovaries. Also, the frequency of new CL found in the same ovary as carried the CL of pregnancy was lower than the expected frequency during the first 20 days postpartum but increased at later intervals ($P < .005$). (03 31 037)

e. Studies on the postpartum dairy cow. An experiment was conducted to study the effects of suckling as compared to removal of calf at birth on the pituitary, ovary and uterus in the postpartum dairy cow. Cows were killed at fixed intervals after calving (day 1, 10, 20 and 30) and also at day 6 and 15 of the first cycle and the first cycle after 74 days. Cows neither milked nor suckled came in heat 15 days earlier than cows that were nursing their calves. Ovulations were observed in the non-suckled cows by day 20 while in the suckled cows ovulations were not

observed until day 30. The pituitary FSH activity decreased significantly from day 1 to day 20 postpartum while the LH activity increased up to day 30. However, no differences were observed in the suckled and nonsuckled cows for FSH and LH. The nonsuckled cows tended to have higher prolactin activity. At day 6 of the estrus cycle both FSH and LH were lower than at day 15. On the average FSH activity was greater during the first cycle than the first cycle after 74 days. The number of follicles 5 mm. and greater were less at day 1 when compared to the average of day 10 + 20 + 30. Further, there was a linear decrease in the number from day 10 to day 30 postpartum. The total follicular fluid weight was lower on day 1 when compared to the average of day 10 + 20 + 30.

The total weight of the uterus decreased from 10 to 30 days postpartum. Suckled animals had lighter uteri at 10 and 30 days postpartum while there was little difference at 20 days. The estimated weights of the endometrium, circular muscle, and longitudinal muscle follow a similar pattern.

The thickness of the uterine wall was not significantly affected by interval postpartum. The thickness of the endometrium increased while the thickness of the longitudinal muscle decreased from 10 to 30 days postpartum. Both these layers were thicker in the nonsuckled animals.
(03 31 037)

f. Emmons Blaine farm experimental herd study. The purpose of the study is to evaluate the fertility in postpartum dairy cows divided into high and low genetic groups (milk production) maintained under two levels of feeding and two breeding times after calving.

The experiment is a 2 x 2 x 2 factorial design. The factors studied are:

- (1) Genetic: two levels of milk production.
- (2) Nutrition: average and high concentrate feeding.
- (3) Reproduction:
 - (a) Bred at first estrus postpartum -- cows were allowed a dry period of 30 days prior to calving.
 - (b) Bred at first estrus after 74 days postpartum -- cows were allowed a dry period of 60 days.

High producers had a longer interval from calving to first ovulation than low producers. Feeding regime had no effect on this factor, but cows on high concentrates and high producers had a longer interval from calving to first estrus than those on medium concentrates or the low producers. A higher percentage conceived when bred at 75 day estrus as compared to breeding at first estrus. (03 31 037)

g. Embryo migration in sheep. Migration of small rubber particles placed in one uterine horn of mated ewes was found to be greater after placement in the uterine horn adjacent to the CL than in the opposite horn. No difference in migration in the two horns was found in unmated ewes.

The histology of the two uterine horns and oviducts as affected by longitudinal position, day of cycle and relation to ovulating ovary is being studied in ewes which had a single ovulation each. (03 31 037)

5. Comparative studies of "repeat breeders" and normal cows and heifers. Of 62 cows slaughtered 14-19 days postovulation for embryo recovery at Veterinary Institute, Beit Dagan, Israel, normal cows yielded 60% embryos and repeat breeders 46%. It appears that, at least regarding repeat breeders, embryo losses were just as heavy for the period 14-16 days postovulation as for the period 17-19 days. Embryo size showed considerable variation. In cows where no embryos were found, 12 of 30 (40%) yielded ova from uterine flushings.

Ovarian follicles larger than 10 mm. were always present at slaughter, with no difference in size between normal and repeat breeders or whether or not an embryo was present. CL size was larger 14-16 days postovulation than on days 17-19 in all cows, with or without embryos. However, embryos were connected with heavier corpora lutea - averaging over 25% more in both normal and repeat breeders.

A surprising finding was a high (24%) incidence of cystic corpora lutea (cavity more than 10 mm.), with highest occurrence in winter; 60% of the cases were in normal cows, although these comprised only 40% of animals slaughtered. Significantly, almost half (47%) of these large cavities were found in cases where embryos were recovered.

Average weights of endocrine glands showed consistently heavier thyroids in repeat breeders, particularly when no embryo was found, and heavier adrenals in the absence of an embryo.

In biochemical work the reliability of the progesterone assay method used was clearly demonstrated. Regarding plasma progesterone concentration, it appears that in cycling cows peak levels were reached at about 14 days postovulation, remaining at similar levels until day 19, at which time there was a dramatic drop in concentration, usually to undetectable (< 0.15 microgram %) levels. In inseminated cows, a difference in concentration was evident on day 17 postovulation (cows without embryos had somewhat lower levels). A very marked difference was found on day 19 post-ovulation: cows with embryos had similar or increased plasma progesterone levels, whereas cows without embryos showed a drastic drop, usually to undetectable levels.

Estrogen work was limited this year. Bioassay work indicated that our 24-hour mouse-uterine weight test can replace the Astwood and modified Astwood tests. Plasma estrogen bioassay on limited numbers indicates nondetectable levels of estrogen in the majority of pregnant cows 19 days postinsemination. Biochemical assay of estrogens has been concerned with methodology.

Determinations of sialic acid in endometrium of cows 18 and 19 days post-estrus showed no significant differences between pregnant and nonpregnant cows. (03 31 049)

C. Poultry

1. Mechanisms controlling ovulation and oviposition. Preliminary studies, reported in 1966, indicated that crude hypothalamic extracts induced ovulation when infused slowly directly into the adenohypophysis of the chicken or into the jugular vein of Coturnix quail. A recent and more extensive study has demonstrated the existence of hypothalamic humoral substance(s) capable of inducing premature ovulation by intrapituitary infusion. Substances tested included (1) crude acid extracts of chicken stalk-median eminence (SME), neural lobe and cerebral cortex, (2) SME purified by gel filtration on Sephadex G-25, and (3) synthetic oxytocin, arginine vasotocin and other pharmacologically active substances present in the hypothalamus. Infusion of SME extract equivalent to 20 mg. wet weight of fresh tissue evoked ovulation in 15 of 21 hens; levels of 5 or 10 mg. were ineffective, while 40 mg. prevented ovulation. On gel filtration of SME, the peak of releasing activity was found to overlap the peak of oxytocic and vasotocic activity as determined by hen and rat uterine assays. Infusion of 500 µg of lyophilized powder from this fraction induced ovulation in 13 of 21 hens. Since intrapituitary infusions of physiological levels of neural lobe extracts, oxytocin or vasotocin did not evoke ovulation, it was suggested that the ovulating hormone-releasing factor is a small polypeptide different from known median eminence hormones. (03 29 045)

Hypothalamic neurosecretion in the neurohypophysectomized hen was studied by histological procedures. Hens, neurohypophysectomized between 26 and 29 hours before oviposition, were killed one hour before, or within one minute following lay to observe the quantity of aldehyde-fuchsin stainable material (AFM) in the hypothalamic neurosecretory system. In hens killed before lay, there was an extremely heavy accumulation of AFM along the supraoptico-hypophyseal tract and only a slight accumulation at the cut end of the infundibular stalk. An expected increase in the store of AFM in the anterior median eminence did not occur. Oviposition was associated with an apparently abrupt depletion of AFM from the supraoptico-hypophyseal tract and a slight loss of AFM from the cut end of the stalk. No loss occurred from the median eminence depot. Normal or sham-operated hens showed no tendency to accumulate excessive amounts of AFM in the hours before lay, or to deplete AFM from any part of the neurosecretory system during lay. These histological observations support earlier evidence (Opel, H., Anat. Rec. 153:396, 1966), based on bioassays, that oviposition in neurohypophysectomized hens results from a regulated release of hormone from some as yet unidentified site in the hypothalamo-hypophyseal system. (03 29 045)

Using a method for adenohipophysectomy in Coturnix quail described in the 1965 report, the time of release of pituitary gonadotrophin for ovulation has been estimated. Mature laying hens, individually caged under electric lights from 6 a.m. to 8 p.m., were hypophysectomized between 9 a.m. and 4 p.m. for effect on the second or third ovulation of sequences of six or more eggs. The ovulations were expected between 5 and 7 p.m. Ovulation was prevented in 20 of 20 hens hypophysectomized before 11 a.m., but was not affected in any of 20 hens hypophysectomized after 2 p.m. The most frequent interval between gonadotrophin release and ovulation appeared to be four to six hours, a value identical with that reported by Rothchild and Fraps (Endocrinology 44:134, 1949) for the chicken. (03 29 021)

2. Parthenogenetic reproduction. A cooperative program was initiated in 1961 with Pennsylvania State University (PSU) to obtain additional information on roles of genetic factors and of fowl pox virus in parthenogenesis. Two closely related groups of Pozo Gray turkeys were maintained, a vaccinated group at the Agricultural Research Center (ARC), Beltsville, Maryland, and an unvaccinated group at PSU. This five-year study showed (1) parthenogenesis (unorganized type) can be increased through selection without fowl pox virus, and (2) all embryos from Pozo Gray turkeys appeared in eggs of vaccinated stock or in eggs of progeny of vaccinated birds. Beltsville Small White turkeys, some selected, others unselected for parthenogenesis, were also included in the tests. Seventeen well-developed embryos appeared in eggs of unselected but twice-vaccinated birds, only one appeared in eggs of unselected, nonvaccinated turkeys. (03 29 019)

Studies of parthenogenetic development in Beltsville Small White turkey eggs were continued in 1967. A total of 2,474 unfertilized eggs from 65 virgin females were examined following a 9-10 day period of incubation. Of these, 980 or 39.6% of the eggs were classified as positive; a somewhat lower percentage than that encountered in the two previous years. Of the 980 eggs classified as positive for parthenogenetic development, 578 or 59% showed an unorganized type of growth; 237 or 24.2% blood and membranes; and 165 or 16.8% contained well-formed embryos. A total of 30 parthenogenetic poults either were helped from the shell or hatched unaided during 1967. Of these, eight poults are still alive. (03 29 019)

Studies on parthenogenesis in chicken eggs were continued in 1966-67. Unfertilized eggs from approximately 170 Dark Cornish and crossbred chickens were incubated at $99\frac{3}{4}^{\circ}$ F. and subsequently broken in water and their blastodiscs examined for evidence of development. A total of 4,930 eggs were examined over a period of approximately 16 months, and 13.7% were found to be positive for parthenogenetic development. Most of the development encountered was of the unorganized type with very few parthenogenetic eggs differentiating to the extent that blood or embryos were present. One live parthenogenetic embryo was encountered at ten days of incubation. Three additional embryos were found, all of which died at approximately four to seven days. (03 29 019)

An attempt was made to induce parthenogenetic development in Japanese quail with use of live fowl pox virus. The treated birds were vaccinated at one day of age and again on reaching four and eight weeks of age. To date, two of 1,536 eggs examined from virgin vaccinated females have shown macroscopically observable development when examined after 9-10 days of incubation. This is in contrast to three parthenogenetically developing eggs encountered among 510 unfertilized eggs from nonvaccinated controls. (03 29 019)

A study was conducted on the incidence of parthenogenetic development in eggs of 163 Beltsville Small White turkeys during their first and second laying year. On the average, the overall incidence of parthenogenesis was higher during the first laying year, 44.4% as compared to 40.3%. The most pronounced difference was in the number and viability of parthenogenetic embryos. A total of 697 embryos were encountered in 7,750 eggs (9.0%) produced during the first laying year and 165 embryos in 5,341 eggs (3.1%) during the second year of production. On the average, viability of embryos was greater in eggs of first year hens. Survival of embryos in eggs during the first year averaged 13.1 days. This is in contrast to an average of 9.0 days survival for embryos in eggs produced during the second year. (03 29 019)

3. Homograft reaction and immunological tolerance in birds. The 1965 report contained results of a preliminary experiment which indicated that hybridization of chickens with turkeys was inhibited by semen injections administered prior to insemination and by repeated artificial inseminations. These results have now been extended by a similar second experiment.

Twelve sets of four full sisters were obtained from a purebred Beltsville Small White turkey flock and 12 chicken males, in good semen production, were chosen from a Dark Cornish flock selected for a high frequency of parthenogenetic development. Each of the sister quartets had one of these males assigned as its specific semen donor. All birds were housed in individual cages. Each egg from each hen was placed in the incubator on the day of lay and remained there for 9-10 days before being examined for embryonic development. The experiment was divided into three intervals. The first was a preinjection period during which all eggs were examined for parthenogenetic development. The second interval, immediately following the first, was a three-week injection period during which two hens of each sister quartet received intraperitoneal injections of at least 0.1 ml. whole chicken semen in complete Freund's adjuvant twice each week. Concurrently, a third sister of each quartet received injections of adjuvant alone. The fourth sister was retained as an uninjected control. The third interval, the insemination period, began seven days after the last injection. Each hen was artificially inseminated once each week for six weeks with not less than 0.1 ml. whole chicken semen from the previously assigned males. During the preinjection period, the incidence of parthenogenetic development in incubated eggs from hens subsequently to be semen injected, adjuvant injected, or uninjected was 17.0, 17.1,

and 20.9%, respectively. The incidence of parthenogenetic embryos in the three respective groups was 0.3, 0.9 and 1.7%. None of these developed beyond the two-day embryo stage. In the injection period, the incidence of parthenogenetic embryonic development remained low. During the first 21 days of the insemination period, the percentage of eggs undergoing embryonic development rose to 33.2 in semen-injected hens, 81.7 in adjuvant-injected hens, and 52.3 in uninjected hens. The incidence of embryos in the three groups was 4.1, 28.3 and 13.1%, respectively. Twenty-two eggs produced identifiable hybrid embryos; three of 262 (1.1%) from semen-injected hens, seven of 60 (11.7%) from adjuvant-injected hens, and 12 of 153 (7.8%) from uninjected hens. No more hybrid embryos were found in eggs laid after the eighteenth day of the insemination period. During the final 21 days, the percentage of eggs undergoing development fell to 14.2, 28.0 and 21.7 in the three respective groups. Similarly, the incidence of embryos declined to 0.8, 1.3 and 1.7%, respectively.

These data have again shown that (1) intraperitoneal injections of turkey hens with a chicken semen-adjuvant mixture, prior to artificial insemination by the same semen donor, can suppress the ability of their subsequent eggs to undergo hybrid embryonic development, and (2) that a long period of weekly inseminations of turkey hens with chicken semen will not necessarily produce long lasting hybrid fertility. A hypothesis has been proposed to explain these results on the basis of the turkey hens having reacted immunologically to antigens associated with the chicken semen. (03 29 020)

D. Sheep and Fur Animals

1. Induction of fertile estrus in ewes during anestrus. Mature white-faced ewes at Dubois, Idaho, were used to determine the effects of the progestogens MAP, MGA and a progestinated vaginal sponge containing flurogestone acetate. The progestogens were given for 16 days to lactating ewes during anestrus. PMS was given on days 17 and 33. The percent ewes lambing and lambs born per hundred ewes treated for the MAP, MGA and flurogestone acetate sponge treatments were 39 and 65; 27 and 38; and 15 and 17, respectively.

In contrast to the results in lactating ewes in mid anestrus, dry ewes in late anestrus responded favorably to flurogestone acetate impregnated vaginal sponges and one PMS injection given at the time of sponge removal. Forty-seven percent of the ewes were diagnosed pregnant at laparotomy about 20 to 40 days after breeding. No controls or ewes receiving the sponges only came in heat during the breeding period. (03 33 005)

2. Effects of route and time of PMS injections on ovulation in ewes. Thirty-eight mature range ewes at Dubois, Idaho, were allotted to treatment groups at random in a 2 x 2 factorial design. All ewes were treated with progestinated sponges for a 13-day period to synchronize heat. PMS (1,000 i.u.) was given either as a single subcutaneous or intramuscular

injection at the time of progestinated sponge removal or two days before removal. Neither route nor time of PMS injection in relation to progestinated sponge removal time had a significant effect on ovulation rate. Inasmuch as the intramuscular injection greatly increases the speed and simplicity of administering PMS with no diminution in ovulatory response, it may profitably be used in preference to the slower more laborious subcutaneous route. Removal of progestinated sponges at the time of PMS injection is also more efficient than removing them in a separate operation. (03 33 005)

3. The effects of pregnant mare serum (PMS) on corpora lutea (CL) maintenance in the ewe. Thirty-seven mature white-faced ewes at Dubois, Idaho, were synchronized for estrus using a progestinated vaginal sponge. At 12, 14 and 16 days after sponge removal, a random sample of ewes was injected with either 250 i.u. or 500 i.u. PMS. The PMS did not cause maintenance of CL in any ewes treated on day 12. However, 64% of the ewes treated on day 14 and 15% of the ewes treated on day 16 had CL maintained beyond the normal age in the cyclic ewe. There was no effect of PMS dosage on CL maintenance. (03 33 005)

4. Interaction of season and feed level on ovulation in ewes. One hundred fifty-two mature range ewes at Dubois, Idaho, were allotted at random within initial ovulation rate to the following feed levels: (1) 60% NRC recommendations for maintenance (NRC-M), (2) 90% NRC-M, (3) 90% NRC-M, (4) 90% NRC-M, and (5) 150% NRC-M. Feed treatments were started, following initial laparotomy, on September 2. On December 21, treatment group 2 was reduced to 60% NRC-M and group 4 was increased to 150% NRC-M. All other treatment groups remained the same. The numbers of corpora lutea (CL) were observed at laparotomy on October 11, December 20 and January 27 in addition to the initial observation on September 1. The changes in number of CL from the initial observation were as follows: October 11, group 1, 0.24; groups 2, 3 and 4 combined, 0.14; group 5, 0.45 (N.S.); December 20, group 1, -.03; groups 2, 3 and 4 combined, 0.14; group 5, 0.55 ($P < .05$); January 27, group 1, -.31; group 3, -.08; group 5, 0.25 ($P < .05$). The changes in number of CL from December 20 to January 27 in groups 2, 3 and 4 which were involved in the feed level change on December 21 were -.23, -.08 and 0.27, respectively ($P < .05$). These results indicate that feed level may have a greater influence on ovulation rate late in the breeding season than at its peak. The seasonal stimulus on ovulation may be so great at the peak of the breeding season that other environmental influences such as nutrition are minimized. (03 33 005)

5. Effects of lactation and hormone treatment on ovulation, estrus and uterine involution in the ewe. Thirty-nine mature, grade ewes at Dubois, Idaho, were divided into five groups and treated as follows during the fall breeding season: (1) nonlactating (lambs removed before nursing); (2) lactating; (3) lactating plus 3 mg. estradiol valerate on day 0 (day 0 = day of parturition), 20 mg. progesterone every other day from days 5-17, 850 i.u. PMS on day 17; (4) same as (3) except 1 mg. 17-

estradiol in place of PMS; and (5) same as (3) except no estradiol valerate on day 0. Laparotomies were performed on days 3, 10, 24 and 38 and autopsy on day 65-70. At each of these observation periods ovarian activity and length and width of the uterine horns were recorded and biopsy taken for histological analysis. Significant differences in time of ovulation occurred among treatment groups. Ovulation had occurred in 5/9 of the ewes in group 1 by day 24, 4/6 in group 2 by day 65-70, 4/7 in group 3 by day 38, 5/8 in group 4 by day 38, and 5/6 in group 5 by day 38. First estrus tended to occur later than first ovulation in all groups except those receiving estrogens where a direct response to these hormones was observed. None of the treatments imposed, time of ovulation or number of gravid uterine horns per ewe significantly influenced uterine horn involution (length and width) or histology (edema, epithelial height and glandular development). The overall arithmetic means for gravid uterine horn length and width in cm., respectively, were: day 3, 54.6 and 5.1; day 10, 42.7 and 3.0; day 24, 29.2 and 2.5; day 38, 29.8 and 2.2; and day 65-70, 27.9 and 2.3. These data indicate that uterine involution is completed by day 24. There was some correlation of histological changes with involution. (03 33 005)

6. A rapid technique for observing the reproductive tract of living ewes. A laparotomy technique using a plastic speculum for rapidly and accurately observing ovarian structures within a peritoneal cavity of the ewe has been described. This technique is used in conjunction with a new laparotomy device (LRD) developed to reduce labor and to make the entire operation more efficient. This method is rapid and accurate, and reduces traumatization, dehydration and bacterial contamination of the reproductive tract. This improved technique appears to reduce adhesions to a negligible level and makes practical the selection of ewes on the basis of ovulation rate. (03 33 005)

7. Relationship of number of corpora lutea (CL) observed at laparotomy to fecundity in two and three year old ewes. Yearling ewes (nulliparous) which had 1 CL when observed and were bred at a subsequent estrus produced 1.07 lambs per ewe when they were two years old. This may be compared to 1.40 for those which had 2 CL when observed at laparotomy. The same figures for the two year old ewes (primiparous) are 1.15 and 1.42, respectively. When the number of CL were observed at the same estrus period that breeding occurred, yearling ewes which had 1 CL produced 0.92 lambs and ewes which had 2 CL produced 1.48 lambs. The same data for the two year old ewes was 0.90 and 1.51. (03 33 005)

8. Pregnancy diagnosis in sheep. A total of 1,940 determinations of pregnancy were made on ewes at Beltsville, Maryland, and El Reno, Oklahoma, between August 1, 1966, and April 4, 1967, using an ultrasonic technique. Determinations on 159 ewes bred to lamb twice a year, at El Reno, were 91% accurate; the average length of time between diagnosis and lambing was 59 days and pregnant ewes averaged 1.7 lambs each. Determinations made on 282 ewes bred to lamb in the fall, at El Reno, were only 77% accurate; the

average length of time between diagnosis and lambing was 74 days and pregnant ewes averaged 1.5 lambs each. Fifty-two percent of the error in this group was accounted for by calling ewes nonpregnant that had singles 75 or more days after diagnosis and by ewes having multiple births 85 or more days after diagnosis. Slight changes were made in the technique following the observations at El Reno, Oklahoma. Of 977 determinations made on ewes in the regular breeding flock and on ewes used for nutrition studies at Beltsville, 97% were accurate; average length of time between diagnosis and lambing was 62 days and pregnant ewes averaged 1.6 lambs each. A total of 522 determinations were made on ewes in continuous breeding at Beltsville, (at approximately monthly intervals) with an accuracy of 99%. Multiple births were detected at an average of 85 days prior to lambing. Ewes bred during the regular breeding season, at Beltsville, were checked for pregnancy in early December. Nonpregnant ewes were then put into breeding for a three week period; 57% of these ewes became pregnant and lambed. (03 33 026)

9. Estrus control in farm sheep. The breeding flock at Beltsville has been divided into three groups prior to breeding to test the use of estrus synchronization for more efficient management at lambing time. One group was fed an oral progestogen (MAP), another group was exposed to vasectomized rams, and a third group served as a control. Results for 1965-66 for matings resulting in pregnancy gave 39% for the second week of synchronization, and 22% for the third week of synchronization for the progestogen treatment. Corresponding percentages were 23 and 21 for the vasectomized rams, and 19 and 36 for the controls. The percent of lambs weaned of ewes bred was 97 for the progestogen treatment, 92 for the vasectomized rams, and 103 for the controls. This year's result showed no advantage in using synchronization of estrus as a management tool. (03 33 006)

10. Reproduction of marten in captivity. One litter of four marten kits was born at the Petersburg Station in 1966 after three years without any production from a herd of 11 males and 21 females, some of which had previous records of having young. All except one of these animals are second or third generation raised in captivity at this Station. Polygamous mating has been practiced. Males have been sperm checked in an effort to insure conception and general health has remained good.

The 1966 breeding season was particularly active. Seventy matings and/or mating attempts were observed on 14 different females. The first mating attempt took place on July 5 and the last on August 22. Three litters were born during April 1967.

Some sugar has been added to the diet in 1967. To date breeding has been active as in the previous year. (03 34 003)

11. Feeding dienestrol diacetate to mink. The question has been raised that chicken viscera fed to mink might contain sufficient dienestrol

diacetate, a synthetic estrogen, to interfere with reproduction. Two experiments are under way at Ithaca, New York, to determine how much dienestrol diacetate is required to interfere with reproduction in mink and to determine how much of this product is present in poultry byproducts.

During the reproduction season of 1967, graded levels of dienestrol diacetate (0, 5, 10 and 20 micrograms of dienestrol per mink per day) were fed to 65 female mink. The control group contained twenty females and each treated group contained 15 females. The reproductive performance per female kept was respectively 2.65, 2.07, 0.66 and 0.0, and the number of kits per litter was 3.53, 3.10, 2.0 and 0.0. These data indicate that the harmful level of dienestrol diacetate to female mink for reproduction is approximately 5 micrograms per mink per day.

Work to determine levels of dienestrol diacetate which mink might receive due to variation in times of withdrawal and handling of poultry byproducts is just being initiated. (03 34 004)

12. Effect of light on reproduction in mink. Studies in cooperation with the University of Wisconsin have shown that female mink and ferrets and a single male ferret when blinded in the fall reproduced normally and comparable to the controls in the following spring. This indicates that the effects of length of day on reproduction are not transmitted solely through the eyes. (03 34 004)

E. Swine

1. Improve reproductive efficiency of swine

a. Phospholipid composition of boar spermatozoa and seminal plasma. Semen was collected from four 14-month old crossbred littermate boars on two collection frequencies, 4 x in 12 days and 12 x in 12 days. The semen was used to determine the phospholipid composition of boar spermatozoa and seminal plasma. Total spermatozoa per ejaculate was significantly lower on the 12x/12 day frequency. There was no difference in phospholipid content or component phospholipid content due to frequency. Total phospholipid for spermatozoa and seminal plasma was 1.8 mg./10⁹ sperm and 22.1 µg./ml., respectively. Component phospholipids were separated by thin-layer chromatography. Mean values for major phospholipids determined in spermatozoa and plasma were: choline phosphatides 42.2%, 10.7%; ethanolamine phosphatides 25.4%, 29.9%; sphingomyelin 15.3%, 33.7%; serine phosphatides 5.7%, 12.4%. Twenty-one fatty acids were identified in spermatozoa phospholipid. Palmitic and stearic acids were the major saturated fatty acids present. The specific identification of the various phospholipids and their component fatty acids add significantly to our basic knowledge of boar semen biochemistry. It will aid in determining the role that the lipid fraction of spermatozoa and seminal plasma play in sperm cell metabolism. Further, this information is needed to help resolve the problem of freezing boar semen. (03 32 007)

b. Reproductive performance of boars selected on the basis of backfat thickness. The effect of genetic selection on semen production and sperm cell composition was studied in six aged Duroc boars. Two boars from each of three lines selected for ten generations solely on the basis of backfat thickness were used. Semen was collected two times per week. Mean values for a nine-week period for total volume (ml.) and total spermatozoa per ejaculate ($\times 10^9$) were: high Duroc 196.4, 35.6; low Duroc 165.9, 37.3; control Duroc 196.2, 52.5. Mean values for total lipid (mg./ 10^9 spermatozoa), phospholipid (percent of total lipid), phospholipid (mg./ 10^9 spermatozoa) were: high Duroc 2.39, 79.96, 1.92; low Duroc 2.69, 73.84, 2.02; control Duroc 2.33, 70.58, 1.64. Boars were necropsied at two years of age. Mean testis weights (gm.) for the high Duroc, low Duroc, and control Duroc boars were: 275.9, 308.5 and 399.5, respectively. Mean sperm cell production per unit of testicular tissue was similar in all lines. There was a significant reduction in the total sperm cell production between high Duroc and control Duroc and low Duroc and control Duroc lines. Differences in spermatozoa lipid were not significant. These data show that intensive selection for both high and low backfat thickness decreased the size of the testes which resulted in lower total sperm cell production. (03 32 007)

c. Sterilization of boars with cadmium chloride. Twenty-four mature boars were used to study the potential of cadmium chloride (CC) injections as a method to induce sterilization in boars. The boars were assigned to one of six treatments: control, bilateral saline injections, bilateral castration, bilateral CC injection, unilateral castration, unilateral castration plus CC injection. Each treated testis was injected with 100 or 200 mg. of CC. Both levels were effective in causing sterilization. Twelve boars were necropsied 25-40 days posttreatment. The individual testis weight of the CC treated boars was reduced by 50%. The 12 remaining boars were necropsied at six months of age. In boars that received unilateral injections, the effects were restricted to the injected testis, the contralateral one remained unaffected. Accessory organ weights of the CC sterilized boars were similar to the controls but were significantly smaller than those of the castrates. Histological preparations from CC treated boars showed functional Leydig cells. In a more recent experiment, some boars regained their capacity to produce a limited number of sperm cells at five months. These data show that a single intratesticular injection of cadmium chloride may be an effective way of sterilizing boars. This method may provide an inexpensive and simple procedure to sterilize boars at all ages. It is simpler than surgical castration and reduces stress. It also might be used in premarket weight boars that would be treated at a predetermined time before marketing. This would be an advantage since the endocrine balance of the boar favors nitrogen retention and enhances deposition of protein over that of the barrow. (03 32 007)

d. The effect of ICI 33,828 on reproductive performance of boars.

Semen was collected two times per week from yearling boars to study the effect of ICI 33,828 (MATCH) on reproductive performance. Two boars served as controls. Four boars were fed either 100 or 200 mg. of (MATCH) per day for 180 days. The treatment with ICI 33,828 resulted in a 20 to 40% reduction in the sperm cell number and gel production. The total volume of the ejaculates of the treated boars was reduced 30 to 60%. At necropsy, the testicles and accessory organs were 30 to 60% smaller than those of the controls. Testicular lipid per gram of wet tissue and the fructose concentration of the semen were reduced in the treated boars. These effects can be interpreted to imply that the administration of (MATCH) blocked or prevented the release of pituitary gonadotrophins. Studies of this nature may prove important in determining compounds that are effective in introducing sterility in the male. Also, they can provide information that will aid in elucidating the mechanisms and the interrelationship of the pituitary and the testis and the subsequent effect on the accessory organs and the production of sperm cells. (03 32 007)

e. Synchronization of estrus.

Past studies have shown that the use of ICI 33,828 (MATCH) was effective in synchronizing estrus in gilts and had no adverse effect on ovulation rate, fertilization rate, or embryo survival. Also, the effective dosage level and duration of the feeding period were established. The compound was used this past year in an applied situation, in a swine production unit, to study the subsequent effect on litter size. One hundred eighty 7 month old cycling gilts were randomly assigned to six groups of 30 each and placed on the compound. The gilts were fed a dose level of 125 milligrams per day for a period of 20 days. Eighty-seven percent of all the gilts treated came into estrus on the fourth, fifth or sixth day after the end of treatment. Eighty-nine percent of all the gilts bred conceived. One hundred thirty gilts were held to farrow. The average litter size was 10.0. In the past year (MATCH) has been used to synchronize estrus in swine by all major experiment stations in the North Central Region. Reports show that conception rate and litter size were just as good as those achieved under good current swine management systems. The number of animals bred by artificial insemination has increased from 1,500 in 1965 to 5,500 in 1966. More than 2,000 animals bred by AI service were synchronized with the compound. The use of this compound provides for the first time an economical and practical way for extensive use of artificial insemination in swine. (03 32 007)

f. The effect of intrauterine devices on embryo survival.

Earlier studies showed that the presence of the intrauterine device in the uteri of gilts did not alter cycle length but did interrupt the pregnancy by day 14 of gestation. Polyethylene rods formed into spirals 18 cms. long and 2 cms. in outside diameter were used as intrauterine devices (IUD). One to six IUD were inserted by midventral laparotomy on the first day of estrus into one or both uterine horns of cycling gilts. All gilts were allowed to cycle once after the IUD was inserted and they were mated to fertile boars at the next estrus. The gilts were necropsied on day 3, 4, 8 10 or 14 after breeding. Mean numbers of corpora lutea for control

and IUD gilts were 14.0 and 12.9, respectively. At eight to ten days post-breeding, five of seven controls and eight of ten IUD gilts were pregnant. At 14 days postbreeding, six of six controls and four of seven IUD gilts were pregnant. Viable embryos numbered 55 in the six controls and 14 in the IUD gilts. Thirteen of the 14 embryos in IUD gilts were found in the horns not containing an IUD. The presence of the IUD device simulated a condition that is observed in repeat breeder sows and results in embryonic mortality. The presence of the IUD caused a significant decrease in the weight of the corpora lutea.

g. Effect of exogenous hormones on embryonic mortality. Alterations of corpus luteum function in the cycling and unilaterally pregnant pigs were attempted at one station. Adequate levels of estradiol, progesterone, or a combination of both administered between day 11 and day 30 of pregnancy, were partially successful in preventing the destructive influence of the sterile horn on the pregnancy. Studies of this nature are important in order to determine benefits that might be derived by exogenous hormone therapy with repeat breeder sows. (03 32 010)

h. Influence of temperature and climatic factors on embryo survival and litter size. The influence of climatic conditions at or near the time of breeding on litter size was studied in 937 litters from 1,400 matings over a five-year period at two locations. Variables studied were the extremes and mean wet and dry bulb temperature, relative humidity, and barometric pressure. The variables did not cause appreciable differences in litter size. There was some indication that deviations in wet bulb temperature and temperature the day after mating were more important than mean, dry bulb temperature and temperature on the day of mating. Within the limitations of this study, there was little association between the climatic conditions at the time of breeding and the size of the subsequent litter. (North Carolina)

Sixty-four crossbred sows were used to investigate the effect of high ambient temperatures on reproductive performance. In trial I, one group of sows was exposed to high temperatures (95° F. for seven hours daily) during early gestation, another group to normal temperatures (72° F.) throughout pregnancy, and a third group to outside conditions during the hot summer months at the Fort Reno Experiment Station. In trial II, gilts were subjected to either a cool chamber (74° F.) or a hot chamber (102° F. for 17 hours daily) for one cycle prior to breeding. Animals exposed to the heat chambers had higher rectal temperatures than those confined to the cool chambers or those maintained in outside lots. However, the rectal temperatures for those in the heat chamber declined steadily for the first six days of exposure and then tended to level off for the remainder of the stress period. There were no significant differences in the reproductive performance of sows exposed to moderate heat stress after breeding when compared to control animals maintained outside. The performance of the sows maintained in outside lots through gestation was similar to those confined to the cool chamber. When gilts were exposed to severe heat stress, for one

estrus cycle prior to breeding, there were fewer normal embryos ($P < .05$) at 30 days postbreeding than for gilts maintained in the cool chamber for the same period of time. No significant differences were found in number of corpora lutea or size of embryos at 30 days postbreeding, but there was a tendency for heat stressed gilts to have more dead embryos. Gilts maintained in the heat chamber consumed less feed and lost significantly ($P < .01$) more weight during chamber confinement than those maintained in the cool chamber. (03 32 022)

i. Relationship of net energy to embryo survival. High energy has been shown to increase rate of ovulation and embryo death. The time and cause of death are not clear. Gilts were fed 2.72 or 1.8 kgs. of feed per day for six days each week. One-half of each group was fed ad libitum (flushed) for approximately 14 days prior to breeding. Embryo survival in gilts receiving higher energy levels (flushed) was lower. Later, complete reciprocal embryo transfers between flushed and nonflushed gilts on the same basal rations substantiated these findings. These data suggest an unfavorable environment after the embryo enters the uterus to be the major contributor to embryo deaths in gilts subjected to high energy intake. (North Carolina)

j. Factors influencing estrus and fertility. In an attempt to maximize ovulation rate, four levels of energy intake (4,386, 7,664, 11,015 and 14,375 kcal./day) were given to gilts fed two levels (3, 5 lbs./day) of a preflush regime. Preflush level of energy seemed to exert little influence on ovulation response. Increasing the energy intake from 4,386 kcal. to 7,664 kcal. for the three-week period prior to ovulation increased ovulation rate appreciably. Higher levels (11,015 and 14,375 kcal.) seemed to have little advantage. (03 32 010)

2. The separation of young and old spermatozoa. (PL 480) The specific gravity of bull spermatozoa separated from the upper and lower fractions of an egg yolk column was determined; the values found were 1.0595 and 1.0825, respectively. The effect of seasonal variation and specific gravity on fertility is not available at this time. Tests showed that old spermatozoa were most fragile when subjected to different osmotic pressures. Dry matter content of spermatozoa was found to be 30 to 45%. An increase in lipid content in the sperm cell from the first to the fifth consecutive ejaculate was noted. (03 32 025)

3. Factors acting in long-term storage of sperm in vivo. (PL 480) Para-cresol was present in ram epididymal fluid, seminal plasma, and blood serum. Analysis of spermathecal fluid revealed the presence of glucose, fructose, and sucrose. Maltose and trehalose are thought to be present also. On the addition of a homogenate of the mucosal magnum layer to cock sperm, oxygen consumption was reduced. Uterovaginal junction tissue stimulated oxygen consumption by sperm. A polyethylene cannula was inserted into the vas deferens of the ram to collect epididymal fluid. Two operations were successful and semen was obtained for periods of 42 and 78 days, respectively. (03 32 026)

F. Broadly Based

1. Physiological and biochemical characterization of reproductive tissues

a. Inhibition of estrogen-induced uterine glycogen synthesis by steroid hormones. The action of steroid hormones from other endocrine glands on the uterine glycogenic effects of estradiol was studied in ovariectomized rats. The antagonists used were the steroid hormones secreted by endocrine glands which are classically known to antagonize estrogen. Single doses of cortisol, desoxycorticosterone, progesterone, testosterone and Nilevar, were not able to inhibit the increase in glycogen which estrogen elicits six hours after administration. Multiple doses of these steroid hormones could only inhibit 30 to 50% of the estrogen-glycogen increase. Cortisol was able to inhibit the uterine water and weight increases which estrogen produced although it did not interfere with the glycogen response. Testosterone by itself was found to be somewhat glycogenic. (03 98 002)

b. Inhibition of estrogen-induced glycogen synthesis by non-steroid antiestrogens. Nonsteroidal compounds have recently been developed by the pharmaceutical industry for use as possible anti-fertility and contraceptive agents. Three antiestrogenic compounds which have been produced are MER-25, clomiphene citrate and CN-55,945-27. While the ability of these compounds to inhibit the uterine weight and water responses to physiological estrogen has been determined, their ability to inhibit the glycogen increase has not been reported. Since most of these compounds have a basic molecular structure similar to the synthetic estrogen, diethylstilbestrol, the present studies were undertaken to determine the estrogenic properties of these compounds and to determine the extent to which these antagonists interfere with estrogen action in the uterus.

Single injections of clomiphene, MER-25 and CN-55,945-27, produced an increase in uterine glycogen which was about one-half as great as that produced by estrogen. There was a lag in the action of the antiestrogens; six hours after administration, there was no increase in glycogen over control level. The antagonists were also estrogenic with regard to water uptake, and stimulated increases in uterine glucose, and after a lag, an increase in vaginal glycogen. When given in multiple doses, the antagonists again produced increases in uterine glycogen, water, glucose and in vaginal glycogen. When estrogen was given along with the antagonists, no further increases were observed. The results suggested that these compounds are competitive inhibitors to estrogen at a common site of action. By occupying estrogen receptors, they then interfere with further estrogen uptake and estrogen action. The presence of these inhibitors at the action sites, however, also produces some water, glucose and glycogen increases. (03 98 002)

c. Effects of insulin-reduced blood glucose levels upon uterine glycogen. Estrogen is stimulatory to carbohydrate metabolism in reproductive tissues and produces an increase in both uterine glucose and glycogen. Since this action on glucose transport and metabolism is similar to that which insulin produces in other body tissues, a study was undertaken to determine the interactions of estrogen and insulin in glucose depleted rats. Mature females were fasted for 40 hours and then injected with estradiol, insulin or a combination of both hormones. Insulin inhibited the usual estrogen response of an increase in uterine water and glucose, but was not able to suppress the increase in glycogen in these hypoglycemic rats. As expected, the blood glucose level was markedly lowered by the combination of fasting and exogenous insulin. The extreme hypoglycemia was partially alleviated when estradiol was given in combination with the insulin, demonstrating a definite systemic effect of the female sex hormone. (03 98 002)

d. Uptake of female sex hormones by receptors in the uterus and oviduct. The interaction between estradiol, the female sex hormone, and a specific receptor molecule in reproductive tissues, is a critical and pivotal step in the early phase of estrogen action. Experiments were carried out under both in vivo and in vitro conditions to further define the nature of the initial combination of the hormone with its receptors. Radioactive estradiol was administered to female rats and poultry and the level of labeled estrogen in the reproductive tracts and other tissues determined. In vivo uptake in the uterus and oviduct was only 0.1% of the administered hormone dosage. A smaller amount was taken up if the animals were pretreated with estrogen. The target tissues, uterus and oviduct, took up 5-10X more than nontarget tissues such as liver and muscle.

A detailed time study was undertaken of the kinetics of estradiol binding by surviving rat uterus and chicken oviduct in vitro. Nontarget tissue binding was also characterized and compared to the specific target tissue binding. The target tissues would continue to bind the hormone for three to four hours, whereas nontarget tissues reached a saturation level in one hour. The velocity of the initial interaction during the first 15-30 minutes was the same for both target and nontarget tissues. The total extent of accumulation followed the Freundlich adsorption isotherm, being proportional to the equilibrium concentration of hormone in the incubating medium. (03 98 005)

e. Effects of estrogens on the immature chick oviduct. Estrogens are known to cause an increase in chick oviduct weight and water content but only a few biochemical parameters have been followed. Since energy metabolism is probably accelerated to meet the needs of the growing reproductive tract, oviducal glycogen and glucose, two major carbohydrates, may increase during estrogenic stimulation. The time course of biochemical events was studied in the immature chick oviduct following a single minimal dose of estrogen. Water content, weight, Na, K, Cl, RNA, DNA,

glucose and glycogen were analyzed in the various anatomical portions of the oviduct. The infundibulum, magnum, isthmus, uterus and vagina were studied separately to determine differences in response to exogenous estrogen. Amounts of estradiol from 10 μ g to 1000 μ g were administered to establish a minimal metabolic dosage. While single doses of less than 100 μ g of estradiol did not promote growth as indicated by a weight increase, a dose as low as 25 μ g was completely effective in stimulating a glycogen response, thus indicating that estrogen doses termed subminimal by oviduct weight analysis are capable of eliciting maximal metabolic changes in the oviduct. Estrogen stimulated increases of 100-200% in glycogen, which were approximately the same quantitatively and qualitatively in all portions of the oviduct. (03 98 004)

2. Estrogenic content of blood and urine of cattle and humans determined by the rat vaginal glycogen microbioassay. The new microbioassay for estrogens based upon the increase in glycogen content of the rat vagina at five hours was utilized to study the estrogen content of biological materials. Untreated, unconcentrated human male and post-menopausal urine was devoid of estrogenic activity. Human pregnancy urine, cattle pregnancy urine and nonpregnant cow urine were found to contain estrogens. After acid hydrolysis of the urines and ether extraction, estrogen levels were determined which agree well with published ranges of estrogenic potency of urine by other methods. Some preliminary results were also obtained from a limited number of samples of blood plasma of cows, a biological material which has been difficult to assay in the past because of the extremely low levels of estrogens present. Preliminary studies of the specificity of the vaginal glycogen response for estrogens indicate that other steroids, progesterone, testosterone, cortisol, and desoxycorticosterone, do not affect vaginal glycogen concentration when administered intravaginally, nor do they interfere with the reaction to estrogen when the steroids are given simultaneously. (03 98 002)

3. Antifertility effects of mechanical devices in the rat uterus. Methods were devised for the intraluminal insertion of uterine nylon devices through the vagina and cervix in laboratory rats. These intra-uterine foreign bodies were found to have a contraceptive action. Both implantation and decidualization were prevented in uterine horns having devices. Preliminary results indicated that 70% of ovariectomized rats implanted unilaterally with monofilament nylon, double-S shaped devices, retained them for a two month period. Increases of about 60% occurred in the glycogen concentration of the uterine horns containing these intra-uterine devices. (03 98 002)

4. Secretion of anterior pituitary hormones and ovulation in small ruminants. Experiments were continued to isolate and chemically identify the neurosecretory substances from the hypothalamus which are responsible for the release of pituitary gonadotropins. The existence of

follicle stimulating hormone releasing factor (FSHRF) was tested by injection extracts of stalk median eminence into the adenohypophysis of sheep. Positive responses would be indicated by ripening of follicles in the ovary, the presence of an estrus vaginal smear due to secretion of estrogen from the ovary, and receptivity of the ewe to the ram. Infusions of FSHRF extract to noncycling ewes in the middle of their seasonal quiescent period produced negative results. In two separate trials, infusions to noncycling ewes in the last weeks of their quiescent sexual period (two to three weeks before onset of sexual cycles) produced mature follicles in 66-75% of the ewes and some estrus vaginal smears, suggesting a seasonal insensitivity of the adenohypophysis to the neurogenic factor.

The luteinizing hormone releasing factor (LHRF) in the extracts was separated from protein, oxytocin and vasopressin by gel filtration on Sephadex G50, Sephadex G25 and CM cellulose. Boiling in 0.1 NHCl for 15 minutes did not affect its activity while trypsin completely destroyed the biological activity. Reduction with 1 M cysteine only slightly decreased activity, suggesting that the disulfide bridge is either absent or unimportant for LHRF biological activity. The active fraction appears to be a polypeptide with a molecular weight of 1400-2500. Incubations of LHRF with pituitary homogenates released LH into the medium while incubation of LHRF with pituitary granules did not, suggesting that LHRF acts on the intact cells and on their enzymatic activity rather than on hormone granules themselves. (03 33 031)

5. Water transport through animal membranes: Influence of the pH and the ionic composition of the bathing fluids on the effect of vasopressin. The permeability of animal membranes was studied in vitro to elucidate the mechanism of action of antidiuretic hormone (ADH). The membrane was mounted in a clear plastic chamber separating two fluid-filled compartments and experiments designed to establish the optimal pH and electrolyte concentrations of the fluid bathing the membrane. At a pH of 7.2 optimal calcium ion concentration was 0.22 mEq/liter. The responsiveness of the toad bladder to ADH was tested in solutions containing 0.22 mEq/liter ionized calcium at pH 7.2 and pH 6.85. ADH caused a greater response in sodium transport in the more acid solution. No significant differences were found in ADH stimulated water transport in solutions containing 0, 0.22 and 0.4 mEq/liter ionized calcium. ADH stimulated water transport was inhibited by increasing the calcium ion concentration to 0.8 mEq/liter. (03 31 038)

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AREA NO. 311. FEED EFFICIENCY IN PRODUCTION OF MEAT, MILK AND EGGS

Problem. In the last 20 years broiler feed efficiency increased 40% and further gains are possible. Similar gains in feed efficiency have not been made in the other classes of livestock. The total potential reduction in feed costs is estimated at \$3.45 billion annually by 1980 and involves \$1.624 billion for beef cattle alone. Similarly, feed cost reductions of \$469 million for dairy, \$416 million for poultry, \$90 million for sheep, and \$854 million for swine could be made. A reasonable objective is to achieve 25% of the potential benefits during the next ten years.

USDA AND COOPERATIVE PROGRAM

A. Beef Cattle

Research projects are aimed at increasing pasture and feedlot gains, improving reproductive rates, improving carcass quality and decreasing feed required per pound of beef produced.

Work is in progress at Beltsville, Maryland, six Federally-owned stations and cooperatively at six State experiment stations. There are contracts on increased utilization of grain for beef production with State experiment stations at California, Florida and Wisconsin terminating in 1967 and 1968. PL 480 grants are held by two institutions in Poland, one in Uruguay and one is Israel.

The Federal scientific effort devoted to feed efficiency for beef production totals 6.8 SMY intramural and 1.5 SMY extramural.

B. Dairy Cattle

The program is aimed at increasing basic and applied knowledge in the feeding of dairy cattle. Considerable emphasis is placed on basic research. Studies focus on energy metabolism through energy balance trials, chemical methods for determining nutritive value of feeds and forage, forage evaluation and utilization and nutritive requirements for heifers and cows. The program is conducted by biochemists, nutritionists, and dairy husbandmen.

The research is conducted at Beltsville, Maryland, and cooperatively with State experiment stations at Lewisburg, Tennessee, and Logan, Utah. Contract research is in progress at College Park, Maryland, and Madison, Wisconsin. A PL 480 grant equivalent to \$22,000 annually at the National and University Institute of Agriculture, Rehovoth, Israel, is directed toward liberal feeding of concentrates as a means of higher production. Another PL 480 contract at Poznan, Poland, is concerned with protein compounds of vitamin B₁₂ and its analogs. Other PL 480 contracts are: Nutritional physiology

of different breeds of Indian cattle, Karnal, India; Utilization of low grade forages by Indian cattle, Chandigarh, Punjab, India; Detoxication of free ammonia in ruminants, Zagreb, Yugoslavia; and Effects of composition and physical form of rations on growth and milk production of bovine, Zemun, Yugoslavia.

The Federal scientific effort devoted to this program is 12.8 SMY intramural and 1.0 SMY extramural.

C. Poultry

This is a continuing long-term program of fundamental and applied studies on the improvement of meat and egg production in poultry. Scientists with majors in nutrition, genetics, cytology or biochemistry and minors in statistics or physiology conduct this research.

Research at Beltsville, Maryland, involves the following studies: selection for a nutritional deficiency and the effect of such selection on egg production; the biochemical basis for differences in such lines; selection for response in egg production to "18 hour" days in cooperation with AERD; the biochemistry of mutant hemoglobin types in the fowl; and cytological bases for parthenogenesis and interspecies crosses in birds.

Nutrition research involves the nutritive requirements, digestion and metabolism of poultry, and the nutritive value of feedstuffs. Work is in progress at Beltsville, Maryland. Work at the Southwest Poultry Experiment Station, Glendale, Arizona, has been closed out. Some phases of work at Glendale were carried on in cooperation with the Departments of Biochemistry and Poultry Science of the University of Arizona at Tucson.

PL 480 research projects are in progress or have been initiated as follows: the Animal and Poultry Breeding Department, Ministry of Agriculture, Dekki Gisa, Egyptian Region, U.A.R., is conducting a study to improve and evaluate the Fayoumi and Dandarawi fowl; a study to evaluate native Indian fowl as new sources of germ plasm is being conducted by the Punjab Agricultural University, Ludhiana, India; the University of Udaipur, Udaipur, India, is evaluating the Desi strain as a pure line and in crosses with White Leghorns and Rhode Island Reds; a project is concerned with the influence of different factors on metabolism of vitamin A in chickens at the Hebrew University, Rehovoth, Israel (five years, 1962-67); a project for the evaluation of the protein quality and energy values of feedstuffs available in India, at Punjab Agricultural University, Ludhiana, India, (five years, 1964-69); an investigation of calcium and phosphorus metabolism in chickens and factors influencing shell quality at the National University, Rehovoth, Israel (five years, 1964-69); and a study on the effect of growth hormone on fat metabolism in adult hens at the Agricultural University, Warsaw, Poland.

The Federal program totals 7.9 SMY intramural annually.

D. Sheep and Fur Animals

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen, involving basic and applied nutrition studies in the development of better and more economic feeding practices of farm and range sheep and fur animals. These programs are carried on at Beltsville, Maryland, and Ithaca, New York, in cooperation with Cornell University, and at Dubois, Idaho, in cooperation with the Idaho and Utah State Agricultural Experiment Stations and the Forest Service on sheep. Cooperation is also involved with the Western Regional project #-94 on nutrition of range cattle and sheep. The program with fur animals is conducted at Petersburg, Alaska, and Ithaca, New York, in cooperation with the Alaska and New York State Agricultural Experiment Stations.

There are two grants involving PL 480 funds in foreign countries on nutrition of sheep and goats. One at the Hebrew University of Jerusalem provides for studies on the utilization of different kinds of protein feeds by ruminants at Rehovoth, Israel, and is supported for four years (1965-68) by \$89,927 equivalent in Israeli pounds.

A project at the Balwant Rajput College, Agra, Uttar Pradesh, India, involves investigation on milk and meat potentialities of Indian goats and is supported for five years (1965-70) by \$100,487 equivalent in Indian rupees.

The Federal scientific effort devoted to research in this area totals 2.1 SMY for sheep and 1.6 SMY for fur animals.

E. Swine

This is a continuing program conducted by biochemists and animal husbandmen investigating basic and applied problems in swine production related to nutrition and metabolism. Work is in progress at Beltsville, Maryland.

A PL 480 project on the utilization of amino acids by monogastric animals is underway with the Institute for the Application of Nuclear Energy in Agriculture, Veterinary Medicine, and Forestry, Belgrade, Zemun, Yugoslavia. It has a duration of five years (1966-71) and is supported by \$94,410 equivalent in Yugoslav dinars.

The Federal program totals 1.6 SMY intramural and 0.1 SMY extramural annually.

F. Broadly Based

There is a PL 480 project on the mechanism of lactation at the Department of Applied Pharmacology, The Hebrew University, Jerusalem, Israel. It is supported for five years (1962-67) and is for \$126,767, equivalent in Israeli pounds.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State stations in this area totals 561.8 SMY which are distributed as follows: beef 165.0, dairy 119.2, poultry 125.1, sheep and other animals 61.8, swine 51.7, and cross species 39.0.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Beef Cattle

1. Digestion and metabolism

a. Digestion and balance studies. The addition of 1% urea to an all-concentrate ration based on milo increased digestibility of crude protein and urinary nitrogen loss but did not improve dry matter digestibility or nitrogen retention. Removal of 1% urea from an all-concentrate ration based on corn depressed dry matter and crude protein digestibility and nitrogen retention. (03 30 032)

Nitrogen retention when urea, biuret, urea phosphate and uric acid were the sole source of nitrogen was (percent of intake) 18.4, 16.9, 12.3 and 23.1, respectively. Digestibility of dry matter and gross energy were greater for uric acid when compared to biuret. Fiber digestibility was less when compared to biuret. Fiber digestibility was less when steers were fed biuret compared to the other nitrogen sources. Twenty plasma amino acids and other ninhydrin positive compounds were affected by nitrogen source, time after feeding or the interaction between these. (03 30 032)

Ruminal fluid from cattle fed only nonprotein nitrogen as compared to cattle fed protein nitrogen in purified diets contained lower molar percentages of isobutyric and isovaleric acids. Cattle fed natural diets had greater quantities of these same acids than did cattle fed protein containing purified diets. (03 30 032)

Placing urea into the rumen resulted in a decrease in salivary flow possibly related to high ruminal ammonia concentrations and/or high ruminal pH. (03 30 032)

When feeding cattle a concentrate ration, ruminal pH and the acetate:propionate ratio decreased as intake increased. These changes were not as apparent when a high roughage ration was fed. While EKG patterns were not affected, heart rate and respiration rates increased with increasing feed intake.

Normal diets of concentrates or concentrates plus roughage with and without milk when fed to young calves caused no abnormal changes in the activity of the heart muscle.

The addition of 5% soy oil to a cattle finishing ration based on corn resulted in decreased gains, decreased feed intake and efficiency, increased ruminal VFA concentrations and decreased ruminal ammonia concentrations.

Studies at Kentucky indicate that more starch reaches the lower digestive tract when high grain rations are fed and that the starch is poorly digested in this portion of the bovines' digestive tract. In vitro tests suggest that the addition of certain amino acids (arginine, serine, methionine, valine, glutamic acid) or sulfur may increase starch digestion. (03 30 034)

b. Microbiology. A ruminal microbial population was maintained essentially the same in a continuous fermentation system as in a steer on the same ration (substrate) for a two week period. Protozoal numbers were lower in fermentors. These results suggest that laboratory techniques may be used in lieu of animals for certain ruminal bacteriology studies. Less fiber was digested in fermentors agitated at 175 rpm than at 44 and 88 rpm.

Steers fed uric acid exhibited more ruminal cellulolytic bacteria than steers fed urea and urea phosphate, while steers fed urea exhibited the highest proportion of amylolytic bacteria. A wide variety of ruminal bacteria possessed urease activity.

Cellulolytic cocci from cattle fed urea or soy purified diets were shown to have rather complex growth requirements (e.g., clarified rumen fluid or a branched chain fatty acid). (03 30 046)

2. Nutrient requirements

a. Growth and reproduction. Calves have been born to two cows raised from seven months of age on protein-free diets with urea as the sole source of dietary nitrogen. These cows produced less milk than their identical twins which were fed a natural diet and have now been on the protein-free diets for 38 and 39 months. The cows on the protein-free diet also had lower plasma concentrations of leucine, phenylalanine, tyrosine and proline and higher glycine. (03 30 027)

After implantation of steers with diethylstilbestrol, the blood plasma concentrations of urea, threonine, valine, lysine, histidine, tryptophan and arginine decreased and glutamic acid increased. (03 30 032)

b. Concentrates. At California, steers fed milo steamed at 50 pounds per square inch (psi) for one minute increased feed efficiency when compared to milo treated at zero psi for eight or 20 minutes and 25 or 75 psi for one minute. Digestibility, nitrogen balance and ruminal VFA were not altered. (03 30 033)

Steam process-flaking increased milo intakes and daily gains compared to grinding, reconstituting or steam rolling milo fed to steers at Fort Reno, Oklahoma. (03 30 027 2)

3. Behavior. At Gainesville, Florida, D-limonene, citrus oil, waste fat, urea, salt and certain combinations of these materials have shown promise in controlling voluntary feed intake of cattle. Citrus oil and D-limonene appeared to interfere with normal ruminal fermentation. (03 30 035)

When 25% and 89% hay rations were offered to steers as coarsely ground mixtures or as pellets, speed of consumption (min./kg.) did not vary appreciably on a diurnal basis. Therefore, the diurnal measurements of time at the feeder may be considered an accurate measure of cattle feeding patterns.

Beef cows spend less total time at the feeder during estrus but the diurnal feeding pattern is not changed. Feeding patterns do not change appreciably during gestation except for a decrease in time at the feeder just prior to calving. Cows nursing calves distribute their time at the feeder more uniformly than nonlactating cows.

4. Genetic influences. In an Ohio study three calf crops of straight-bred Herefords and Charolais and reciprocal crossbreds by the same bulls were studied. One-half of the calves were creep-fed, fattened immediately following weaning and slaughtered at slightly over 14 months of age. The other half were not creep-fed, were wintered, grazed for about 60 days, fattened in the drylot and slaughtered at about 20 months of age.

Differences in efficiency of feed utilization between breeds while on feed in drylot were not significant. This was also true when an adjustment was made for the higher maintenance needs of the larger Charolais and crossbred cattle. There was no apparent hybrid vigor in amount of feed needed to produce a unit of gain. (Ohio NC-1 contributing project.)

When the amount of TDN required to maintain the cow was included, the calves which were creep-fed and finished immediately following weaning required the least TDN per unit of slaughter weight. However, these cattle obtained 40% of their energy from concentrates (creep-fed and finishing ration) while those slaughtered at the older age required only 23%. The most efficient system would appear to be the production of a maximum weight of slaughter grade beef at weaning age. (Ohio NC-1 contributing project.)

Sixty-two mature, nonpregnant, nonlactating Hereford and Charolais cows were used in an experiment to study the effect of cow size and condition and protein content of the ration upon energy requirements for maintenance. Complete pelleted rations containing 6.9, 9.1 and 12.0% total crude protein were individually fed to supply digestible energy at theoretical maintenance levels for periods of 12 to 16 weeks, at .75 times maintenance for six weeks, and at 1.25 times maintenance for six weeks. Changes in body weight of each cow were estimated from regression lines fitted to weekly weights.

Height at the hooks was recorded in centimeters and condition was estimated by ultrasonic measurement or a visual score.

When fed at theoretical maintenance requirement there was little average gain or loss of body weight. The average weight change obtained from feeding at .75 and 1.25 times maintenance also approached zero. There were no significant differences in body weight gain or loss between rations or breeds. However, there was a tendency for cows with a high weight-height ratio to gain more than cows with a low weight-height ratio. Cows that had a high degree of finish tended to gain weight while those that were in thin condition lost weight when the amount of energy fed was based on their metabolic weight ($W.kg^{0.75}$). (Ohio NC-1 contributing project.)

Analyses of feed efficiency data independent of intake indicate differences in feed conversion associated with sires. Heritability estimates for gain, independent of feed intake (efficiency of feed utilization) during four successive periods and for 32-week gain were 0.34, 0.41, 0.56, 0.63 and 0.64, respectively. Partial sire and residual correlations, independent of carcass weight, between 32-week gain and weights of loin, rib, round and rump, chuck and their sum were: -.15, -.10, -.17, 0.47, -.03, 0.63, 0.09, 0.46, -.06, respectively.

Optimal slaughter weights for steers produced by breeds of different sizes were found to vary considerably. For example, steers of breeds that gain 1.8 lb./day at ten months (800 lb. mature) should be slaughtered at approximately 650 lb. to gain the maximum amount of beef for feed intake if the ratio of live weight sale price to price of feed is ten; whereas, a steer of 3.5 lb./day gain (1900 lb. mature wt.) would have an optimal slaughter weight of approximately 1300 lb. As the price ratio decreases slaughter weights decrease but to a lesser degree for cattle of slower rates of gain. These slaughter weights project up to 1600-1800 lb. for very high gainers in a favorable ratio (12+) situation. This research provides a basis for comparing efficiency of different breeds of cattle from the standpoint of return on investment as well as pounds of beef produced per unit of TDN. (03 30 015)

5. Sex influences. Bulls and steers were used to test their ability to utilize energy in producing edible product, carcass trim, noncarcass components and average weight on test. The partial regression coefficients of digestible energy consumed on gain in edible product with carcass trim, noncarcass components and average metabolic size (wt. to the $3/4$ power) held constant were 4,570 kcal/kg. in bulls and 8,323 kcal/kg. of edible product in steers, a difference of 47% less energy for bulls relative to steers. The ratio of the estimated energy retained to the energy ingested was .123 in both sexes, suggesting equal efficiency in total energy retention.

Maintenance requirements as estimated from weight to the 3/4 power accounted for the largest fraction of the variation in digestible energy consumed, .493 and .445 for bulls and steers, respectively. The fractions of the variation in digestible energy consumption associated with each of the other variables were small. (03 30 022)

6. Trace elements. Trace element study of soils and forages in Poland showed large year to year and location variations. Vegetation stage had little effect except for a possible decrease in zinc with increasing maturity. Preservation as silage or hay resulted in an increased concentration of the trace elements. (03 30 044)

B. Dairy Cattle

1. Energy metabolism studies

a. Energy requirements of dairy cows for maintenance and pregnancy. The utilization of energy by five pregnant and three nonpregnant Holstein cows fed maintenance rations of 60, 40 and 20% alfalfa hay plus 40, 60 and 80% concentrates were measured in three 3 x 3 Latin square energy balance experiments. Trials were run 243, 193 and 0 days after conception. Nonpregnant cows lost ($P < .01$) less energy as feces and heat and more ($P < .01$) as methane than did the pregnant cows. Urine losses were not affected by ration, pregnancy or cows. Nonpregnant cows gained body tissue while the pregnant cows lost tissue, reflecting the increased maintenance requirements and lower efficiency of energy utilization by pregnant cows. The average maintenance requirements of the dry nonpregnant mature cows was 10.6 ± 0.39 Mcal. of metabolizable energy per 500 kg. body weight. The average maintenance requirement of the cows in the last 60-90 days before calving was 14.1 ± 0.47 Mcal. ME/500 kg. The maximum values obtained with two cows that calved on the last day of the trials were 16.1 and 17.4 Mcal. ME/500 kg. body weight. This is considerably less than the allowance recommended by the current standards that are being used in the United States. (03 30 025)

b. Use of energy by high producing dairy cows. Energy balance studies with dairy cows producing five to 45 kg. milk daily, with milk fat tests ranging from 1 to 6%, and consuming rations with 40, 60 and 80% concentrates plus 60, 40 and 20% alfalfa wafers showed that neither level of milk production nor milk composition influenced the efficiency of utilization of metabolizable energy for milk production. Milk fat tests decreased and body fat formation increased when the proportions of concentrates increased. Metabolizable energy utilization was only slightly improved when the digestibility exceeded 70% DE. Lactation and lipogenesis were equally efficient processes. Maintenance requirements were found to be greater for lactating cows than for dry nonpregnant cows. (03 30 025)

c. Use of purified diets by dairy cows. Pilot studies with cows receiving purified diets indicated that neither the source of soluble carbohydrates nor nitrogen had any influence on the utilization of

metabolizable energy. The amount of purified diet consumed was quite variable among animals. The substitution of 10% of the urea nitrogen by purified soy protein greatly improved the intake of the purified diet by one of the animals. These studies demonstrated that dairy cows can use purified diets containing large amounts of urea very effectively for milk production. The major limiting factor is the problem of achieving adequate feed intake. (03 30 025)

d. Effect of forage type on energy utilization. A study involving lactating dairy cows consuming diets containing 40% of either alfalfa or brome grass hay and 60% concentrate at various levels of intake was completed during the year. Preliminary results indicate that the efficiency of use of metabolizable energy for milk production was nearly identical with these diets. Both diets exhibited a greater decline in digestibility with increasing levels of intake than was observed with the alfalfa and concentrate diets. There was a slight decline in metabolizable energy value at high levels of intake. (03 30 025)

e. Effect of level of feed intake on energy losses. In previous experiments a slight decrease in digestibility at high levels of feed intake was noted. In these experiments, however, the losses of urine and methane were proportionately less at higher levels of intake so that the metabolizable energy value of the diet remained relatively constant. In a more recent experiment involving purified diets and a natural diet consisting of 63% cracked corn, 12.5% chopped alfalfa hay, 12.5% chopped timothy hay, 5% linseed meal, 1% dicalcium phosphate, and 1% trace-mineralized salt, somewhat different results were obtained. The natural diet resulted in a very large depression in digestibility at high levels of intake. This depression amounted to $6.6 \pm 1.3\%$ units per multiple of maintenance (ME intake in kcal/110 kg^{3/4}). The losses of urine and methane declined at high levels of intake, but the metabolizable energy of the diet still decreased by $4.49 \pm 1.24\%$ per multiple of maintenance increased in intake. This is the first diet with which a sizable decrease in the ME value has been noted at high levels of intake. It seems likely that the fact that the corn was cracked, but not ground, was a contributing factor towards the very large decrease in digestibility. The digestibility of the purified diets decreased by $4.2 \pm 1.3\%$ per unit increased in intake but the ME value of these diets did not decrease significantly. (03 30 025)

f. Automatic data logging system. Installation of additional components to the data logger made possible the recording of a second measurement of the exhaust gas volume from each chamber. This has aided greatly in routine checking of the respiration data. The additional components included 18 telephone-type stepping switches (three for each chamber) mounted in a separate cabinet, and the necessary wiring and programming changes in the logger circuitry.

The recording of the amount of time each animal spends standing has been improved by the addition of photo cells at each chamber. While the animal

is standing, the light beam is interrupted. This causes an electrical contact to be closed so that the information may be recorded by the data logger. The data logger has proved to be very reliable. During the year a total of 209 energy balance trials involving 626 24-hour respiration periods were completed, and during the same period the total cost of repairs to the logger amounted to \$98. Use of the data logger has meant a very substantial savings in the cost of conducting these measurements. (03 30 025)

g. Computer use. Excellent cooperation by the staff of the Biometrical Services Unit has made possible the summarization of several completed experiments and initial summarization of several others. In addition to the routine computation of the results of individual energy balance trials, special attention has been given to statistical analyses, linear and multiple regression analyses, data plotting, and computer-prepared tables of original data to be published as USDA Technical Bulletins.

Several computer programs were written by laboratory personnel to assist in completing these projects. The 246 "A" program was extensively revised to provide more complete summarization of original data recorded by the data logger. This program now summarizes the respiratory gas analysis data in addition to the corrected exhaust gas volume, and also provides a considerably greater number of checks of the original data. The incorporation of the gas analysis summary into this program will greatly reduce the amount of data which must be manually punched onto cards. (03 31 025)

h. Ruminal infusion studies. Pilot studies in which acetic and propionic acids were infused into the rumens of cows receiving a diet of cubes containing 80% concentrates and 20% alfalfa showed no significant differences in the utilization of these acids for milk production or body fat formation.

2. Rumen and forage biochemistry. The previous discovery that forage noncell wall matter has a complete digestion in the ruminant digestive system, has been applied to the determination of true digestibilities of a number of rations. The difference between true and apparent digestibility has been shown to comprise matter containing the whole of the metabolic fecal nitrogen. Nitrogen is contained in this fraction derived from feces at 7% and contains virtually no true protein. This matter comprises at least 85% indigestible bacterial remnants (mainly cell walls) and the remainder products are secreted by the animal into the intestine and colon.

a. Fecal bacterial matter. The quantity of the metabolic fraction varies with intake, ration, type of animal--lactating or dry, species; understanding of the factors controlling its fecal output are essential to further progress in increasing precision of feed evaluations.

The yield of bacterial metabolic matter from a given amount of digestible substrate has been measured in vitro and compares favorably with values observed in vivo. The calculated weight of dry weight cells from digestible

substrate is on the order of 30%, a value nearly three times in excess of the quantities presently allowed by known energy pathways. This phenomenon had previously been observed in Bacteroides ruminicola, and has been observed also this year in Bacteroides amylophilus; the latter organism is being studied in detail in regard to its energy pathways. (03 31 022)

b. Microbial metabolism. Bacteroides ruminicola obtains a high dry weight yield from glucose fermentation in batch culture. Other workers have shown that Bacteroides amylophilus and at least two other rumen species obtain high dry weight yields during carbohydrate fermentation. These results raise interesting practical and theoretical questions. For example, do these bacteria conserve more of the potential fermentation energy than most other anaerobes and/or do they require less energy per chemical bond synthesized than most other anaerobes. The answers to these questions require much further research, but will have considerable bearing on and understanding of the efficiency of utilization of various diets by these bacteria, and upon understanding the fundamental metabolic processes in these bacteria.

Carbon dioxide is known to be taken up during growth of many rumen bacteria, and appears to be involved in carbohydrate metabolism via generation of terminal electron acceptors. Carbon dioxide is also known to be involved in other essential metabolic processes of these organisms, e.g., protein and probably also lipid synthesis. Carbohydrate fermentation presumably provides most of the energy for the essential metabolic processes in these bacteria. Studies are continuing using B. amylophilus as a model, to delineate some of the carbohydrate fermentation pathways in rumen bacteria, and to further assess the role of CO₂ in carbohydrate fermentation and other essential metabolic processes in these organisms. (03 31 022)

c. Nonruminant digestion of fiber. Other nutritional and chemical studies have been initiated in investigating the microbial digestion of cellulose and hemicellulose in cattle, sheep, rats and swine. Nonruminants appear to have extensive digestion of hemicellulose in the lower tract and overall digestion of hemicellulose always exceeds that of cellulose. Ruminants digest cellulose to an equal or greater extent than hemicellulose of the same forage. The purpose of these studies is to develop reliable bases for evaluation of forages and feeds for nonruminants based on chemical composition. (03 31 022)

d. Heated feeds. Studies have continued on the chemistry of heated feeds and the nutritive availability of proteins. Previous studies had shown the involvement of the Maillard reaction in binding amino acids with a carbohydrate fraction into an indigestible condensate. Further work has shown that hemicellulose as well as sugars are active participants in the reaction. Temperature, time, moisture and pH were studied. The effect of time varied depending on the particular forage sample used. The temperature causing some heat damage was between 40° to 60° C. Results of pH study indicate that under silo conditions, the higher pH enhances

browning. In the 20 to 70% moisture range, forages were more susceptible to browning. These investigations also show that different samples of forages have different susceptibilities to heat damage. The nitrogen insoluble in acid-detergent was used as the assay method for heat damage analysis. This method was compared to pepsin-insoluble nitrogen assay and found to be a suitable assay where the availability of protein is in question. (03 31 022)

e. Silica. Although it has been well established that silica is metabolized by many species of plants, its presence in forages is often regarded by nutritionists as no more than soil contamination. Nevertheless, silica that is absorbed and metabolized by forage grasses has been found to be an exceedingly important factor in the reduction in digestibility of structural carbohydrates. In some species--e.g., reed canary grass, and possibly Coastal Bermuda grass and tall fescue--silica rivals lignin in importance. An average decline of 3.0 units of digestibility per unit of silica in the dry matter has been found. This correction has been incorporated into the Summative Equation. (03 31 022)

f. New methods. An indirect method for lignin utilizing permanganate has been developed as a means of allowing the determination of cellulose and insoluble ash in the same sample. The insoluble ash is an estimate of silica content, which in many grasses is a primary factor in reducing digestibility. The new permanganate lignin method is intended as an alternative procedure to the 72% sulfuric acid method, compared with which it offers definite advantages as well as certain disadvantages. Choice of methods will depend on materials analyzed and on the purpose for which the values are to be used.

Advantages of the permanganate method over the 72% acid method include a shorter procedure for lignin per se while the residue is reserved for further analysis of cellulose and silica. The permanganate reagents are much less corrosive and require no standardization. The residue requires no filter aids, and lignin values are not subject to some interferences (cutin, soluble lignin, Silanol water) which affect 72% sulfuric acid lignin. Values are less affected by heat damage artifacts and are closer to a true lignin figure. (03 31 022)

3. Development of rations

a. The effect of ration on carotene utilization in calves. Last year, it was reported that the vitamin A status of calves appeared to be considerably better when their ration included some skimmed milk, even though the skimmed milk did not constitute a source of either carotene or vitamin A. This observation is of importance in that it would imply that the carotene or vitamin A requirements of calves would vary dependent upon what the remainder of the basal ration was. Four groups of calves were established and depleted of their vitamin A stores during a preliminary period. The basal ration of all groups was the same and included 70 mg.

carotene/kg. body weight, the source of this carotene being from dehydrated alfalfa hay pellets. The rations differed in that one included skimmed milk, one casein, one lactose and one included water. These rations were fed for periods of twelve to 23 weeks and the carotene vitamin A status was determined from values for plasma carotene, plasma vitamin A and cerebrospinal fluid pressure. There were no significant differences between treatments with respect to vitamin A status. These observations are different from those in the preliminary trial. It is tentatively concluded that dried skimmed milk or its major components, that is, casein and lactose, do not appreciably affect the utilization of carotene from dehydrated alfalfa pellets in the ration of a calf. It is possible that small differences do exist, but an experimental design more precise than the one used and considerably more extensive work would be required to demonstrate any significant difference among the treatments. (03 31 019)

b. Vitamin A metabolism in steers fed corn silage or alfalfa hay pellets. Numerous reports have suggested that cattle, particularly steers, may become vitamin A deficient if they are fed a ration high in corn silage. This appeared to be true even though the carotene intake from this high corn silage ration would seem to be very adequate. This experiment was conducted to determine if, in fact, there were any differences in the efficiency of utilizing carotene from corn silage as compared to carotene from an alfalfa source.

Twelve yearling Holstein steers were paired on the basis of vitamin A and carotene status and assigned to rations in which the carotene source was either corn silage or alfalfa hay pellets. An attempt was made to maintain equal intakes of carotene through a frequent check of the carotene content of the two forages. Nevertheless, some differences in carotene intake did occur. When the observations were corrected for differences between groups in carotene intakes, it was found that no significant differences existed between groups in liver vitamin A and carotene nor in the values for plasma vitamin A and carotene. Thus, it was concluded that the carotene from corn silage was used as efficiently as a precursor for vitamin A as was the carotene from alfalfa. This suggests that any differences in the apparent vitamin A status observed in the field when rations involved high amounts of corn silage are either an artifact or associated with some other factor than the conversion of carotene to vitamin A. (03 31 019)

c. Effects of mechanical treatment on the feeding value of timothy. It has previously been shown that the feeding value of a long forage can be markedly changed by fine grinding. Although this procedure usually depresses digestibility, the intake per day is increased to the extent that animal performance is often improved. This work was undertaken to determine if there might be a degree of physical treatment between the extremes of long hay and fine grinding that would result in an improvement in intake but without a corresponding depression in digestibility. Baled timothy was prepared as follows: (1) ground through a 3/8 in. screen and made into 3/8 in. pellets; (2) rolled wafers with a nominal

diameter of 2 1/4 in. and a nominal length of 9 1/2 in.; (3) chopped before feeding; and (4) baled. These forages were fed to four fistulated Holstein heifers in a 4 x 4 Latin square design for the measurement of intake, digestibility and volume of rumen contents. The particle sizes represented by these treatments ranged from very fine in the ground and pelleted material to full length grass in the baled material.

Dry matter intake was the greatest under the pellet feeding regime and least when feeding baled and wafered forage. The intake from chopped forage (intermediate particle size) was intermediate. Conversely, dry matter digestibility percentage was lowest in the pelleted feed and highest on the wafered and baled. Again the intermediate particle size (chopped) was intermediate in this respect. The combined effect of differences in intake and digestibility was such that the intake of digestible dry matter per day in the chopped feed was significantly higher than on the baled or wafered feeds.

This is the second experiment which has indicated that there is a degree of particle size reduction that will increase intake over long material yet not produce any significant depression in digestibility. This suggests that for a particular forage, there may be a particle size which is optimum from the standpoint of highest efficiency of gains. This concept has rather wide practical implications in terms of making the most and utilizing the best of our forage resources and it should be explored further at the earliest opportunity. (03 31 030)

d. Comparisons of nonprotein nitrogen sources. The substitution of nonprotein nitrogen for plant protein in rations is a very attractive practice from the standpoint of economics, but is feasible only within certain definite limits. One of the primary limitations on the use of these cheap protein substitutes is the formation of high levels of ammonia in the rumen and blood when urea is used as the primary source of non-protein nitrogen. An alternate source of nonprotein nitrogen became available in the form of a urea-wax clathrate. Initial observations on this material were encouraging since the level of rumen ammonia reached only 83% of the value that was obtained when feeding urea in the same amounts. This observation led to a nitrogen balance trial. Results of the trial were somewhat disappointing in that it was observed that nitrogen retention from the urea-wax form was 25.4 mg./day as compared to 31.9 gm./day when the ration contained simple urea. Feed intake and daily weight gains were similar with both nitrogen sources.

Ordinarily, the reduction in rumen ammonia levels should result in an increase in the nitrogen retention. The unexpected results observed cannot be explained on the basis of greater dilution of ammonia in the case of the urea clathrate ration nor on the basis of reduced further digestibility when feeding the clathrate form. At this point, no satisfactory explanation of these relationships has been developed nor revealed in a search of the literature. The work indicates that alternative sources of nonprotein

nitrogen cannot be evaluated solely on the basis of rumen ammonia levels, since these are not always indicative of the relative rates of nitrogen retention. Because of the important economical considerations, the search for other methods of improving nonprotein nitrogen utilization in the ruminant will continue. (03 31 021)

e. Measuring rates of passage in the digestive tract. Voluntary consumption rate is a very important factor in determining the actual feeding value of a ration of forage. Therefore, full forage evaluations depend ultimately on an understanding of the potential intake level of the forage in question. It is likely that in most situations the rates of digestion and passage of forages in the tract are important factors in limiting the intake. In order to develop, understand and test the relationships between rates of passage and intake, reliable methods of measuring passage rates and rates of digestion must be developed. In this connection, primary consideration is given to the cell-wall constituent fraction since this fraction seems most likely to be the one limiting space available for additional intake.

The stained particle technique has been used in previous work here and at other laboratories to estimate the rate of passage. The method has been criticized because it assumes that passage rate is not related to the particle size appearing in the feces and gives little consideration to quantitation and finally it gives little or no consideration to the appearance or disappearance of those stained particles which cannot be seen under low magnification.

The present experiment involves the feeding of C^{14} labeled cell-wall constituents, frequent sampling from rumen and duodenum fistuli and feces. The samples obtained were sieved for quantitative estimates of the various particle size classifications and the determination of C^{14} activity in each fraction. This measurement of C^{14} activity of the samples obtained allowed an estimate of the length of time since feeding that each particle size had experienced. Thus, length of time in the digestive tract could be determined independently of the size of the particle. It was found that larger size particles disappeared from the rumen faster than smaller ones but that smaller particles passed through the tract more rapidly; thus, there was a great deal of physical breakdown of the larger particles to smaller before passing from the rumen. This would constitute an important factor influencing the rate at which particles of a given size appeared in the feces. Thus, any method of estimating passage rate that ignores this phenomenon and overlooks the quantitation of very fine particles will be seriously biased. The findings have made a significant contribution to our ultimate ability to predict the rate at which forages will be consumed, digested and passed through the digestive tract. (03 31 018)

4. Improvement of forage resources

a. Alternative silage crops compared. Starr Millet and RS 610 grain sorghum silages were compared with respect to their value for a milking herd

in the successive years. The grain sorghum was a superior crop for this use in both years. Yields per acre, voluntary consumption levels and milk production were in favor of the RS 610. In two other trials low moisture alfalfa orchardgrass (30 and 48% DM) was either equal to or superior to RS 610 silage with respect to consumption and production. Corn silage included in one trial was somewhat inferior to the 48% DM alfalfa-orchardgrass silage. This work was done at Lewisburg, Tennessee. (03 31 031)

b. Effects of variety and cutting schedule on the feeding value of alfalfa hay. At Logan, Utah, sheep were used to determine the digestibility and voluntary intake levels of alfalfa hay which was produced either under a four-cutting per season system or a three-cutting system. The work extended over a three-year period and involved three different varieties of alfalfa. The four-cutting system yielded hay of a generally higher digestibility than for the three-cut system. While varietal differences were not great, the digestibility of Ranger variety was somewhat higher than that of Dupuits and Lahontan. Level of intake tended to be positively associated with level of dry matter digestibility, although intake values were considerably more variable. The amount of time allowed for regrowth of the second cutting was nearly the same under both systems, varying only two or three days. However, second cut material from the three crop system was consistently about two percentage points lower in digestibility than second cutting material from the four crop system. Thus, it appears that an early first cut not only produces hay of a higher digestibility at that point but is a means of improving the digestibility of subsequent crops in the same year. (03 31 032)

c. Treatment of silage with formic acid. In the past, results of feeding direct cut, high moisture hay crop silage have often been disappointing. Poor growth and production have generally been explained by the low intake of digestible energy per day when on this type of feed. The addition of formic acid to direct cut silage at about 1/2% by wet weight has overcome this difficulty in varying degrees in each of three experiments which have been completed. Silage which is treated in this way was compared to undamaged hay in feeding trials with growing heifers. Hay and silages were made from the same crops. It was found that the intake of dry matter from the treated silage was less than the intake from hay and this observation was in agreement with previous observations of untreated direct cut silage. However, the digestible energy content of the silage has been increased to the extent that the intake per day of digestible energy for the animals on silage was equal to that of the animals on hay. The average growth rate over the three trials was just slightly higher for the animals fed on silage. This apparent improvement of digestible energy content of silage through a treatment is revolutionary in terms of our usual concepts of a silage treatment. It promises to be a method which will fill a widespread need for improvement in high moisture silage. Work must be continued to determine optimum rates of application and identify the crops which will be susceptible to this type of improvement. (03 31 030)

d. Feeding value of corn silage as affected by culture of the corn plant.

The characteristics of corn plants for silage can be appreciably altered by variations in the planting density, maturity at the stage of harvest and the variety selected. The effects of these variations on the feeding value of the resulting silage is studied under contract at the University of Maryland. To date no large differences in the feeding value of the corn silages produced have been noted. This has been the case in spite of relatively large differences in percent dry matter and in planting date and in varietal selections. The silages of higher moisture content have been slightly more digestible and the intake has been generally the same when fed to dairy steers. Research to date would indicate that the most advantageous practice would be to raise corn silage in the manner that would yield the highest dry matter per acre since all of the dry matter produced has been about the same value. (03 31 034)

e. Reducing surface spoilage of silage.

Additional information regarding the value of Mylone has been obtained. This fungicide had previously proved to be useful for reducing the anaerobic spoilage on some silage surfaces.

Mylone was applied under a plastic covering to two quadrants of the surface of a fungicidal. The crop was fourth cutting alfalfa wilted to about 55% dry matter stored in late September. The feeding of this material commenced in the following July and continued during the heat of the summer. Surface spoilage tended to increase as the feeding period progressed. However, the application of Mylone did reduce the spoilage from about 1.0 to 0.5 lb. dry matter per square foot in the first half of the bunker that was fed and from 6.0 to 3.5 in the last half of the bunker fed. Total dry matter recovery in this bunker was 94.6%.

In another experiment, 0.1% Mylone was applied to each load of first cutting alfalfa that was stored in a well constructed ground stack. Average moisture content of the crops at storage was 50%. The results of this type storage were unsatisfactory due mainly to damage of the cover by cattle tramping on the top. Sixty-one percent was recovered as good feed and 26% as spoiled material. Dry matter consumption by milking cows of the field cured hay made at the same time was significantly higher than from the reserved portions of the low moisture stack; thus, the influence of Mylone does not appear to be sufficient to overcome the effect of mechanical damage to the seal. No detectable residues of Mylone were found in silage that had been held for two months in quart jar silos. The rates of application included 1.0% Mylone, this being about four times the expected level of use in practice. Further investigation is planned to more precisely define the conditions under which Mylone would be useful and to develop more confidence in the concept that the Mylone residues will not be a problem in feeding. (03 31 030)

f. Effects of heat on silage composition.

The composition of silage is often altered and its value appreciably reduced by the heating which occurs in ground type structures. With such observations, however,

it is impossible to distinguish those changes which are caused by the existence of heat and those due to the oxidation that usually accompanies this heating. Working with quart jars under closely controlled conditions, it was possible to differentiate these effects. When the jars were exposed to a heat of about 60°C, it was found that the greatest damage to the chemical composition occurred early in the storage period. If the heating was delayed until after a four week normal fermentation period, heat damage was much less pronounced. Damage from heat was also reduced but not eliminated if oxidation changes were eliminated by providing very excellent seal. The results indicate that high ambient temperatures will damage silage quality even under excellent storage conditions. However, the effects will be much intensified if coexistent with the heat is an imperfect silage structure. Thus, the structural requirements of silos may be much more demanding when they are to be used in hot climates than when they are to be used in temperate climate regions. (03 31 030)

g. Methods of ensiling small grain forage. Forage from small grain is an important crop in many sections. It is almost always grazed or preserved as silage. Although these make excellent grazing crops, ensiling has been a problem. A very popular method is direct cutting and addition of 10% feed grain. This improves silage quality but is expensive. The possibility of substituting wilting for the addition of grain to these crops is being explored at Beltsville. Winter wheat that had just headed was ensiled or direct cut + 10% cornmeal and as wilted (30% DM). Preliminary evaluation of the data indicates that milking cow response (milk and consumption) was better with the direct cut + cornmeal silage when a low level of grain was fed with each silage. However, when an intermediate concentrate level was added to both rations, response was about equal. The intake of forage only was consistently higher on the wilted silage. Apparently, wilting may be substituted for the addition of 10% cornmeal as an ensiling method, if a liberal level of concentrate is to be fed. (03 31 030)

h. Field losses in the drying of rye and orchardgrass. Previous work with alfalfa has shown DM losses during field drying to be small when mowing is done with a windrower. These observations were extended to include two other forage crops.

Winter rye wilted in the windrow from 81-55% moisture during five rain-free days lost no measurable DM (+3.0%). Cell soluble contents decreased from 40-33% during this period. This chemical change is difficult to resolve in view of the general improvement of silage quality from wilting.

Orchardgrass wilted from 78-69% moisture lost an insignificant 5.6% DM (+2.5%), although 4.1 cm of rain occurred during the five day period. Cell solubles content dropped only from 39-37%. Windrows that lay in the field a total of 27 days (poor drying weather) and reached a moisture content of 17% lost 30% dry matter and contained only 29% cell solubles. These results suggest that previous concern about dry matter lost during any reasonable wilting period may be unjustified. However, greater concern about changes

in chemical composition during wilting and how these relate to feeding value appears to be warranted. (03 31 030)

i. A corn silage-based complete ration. The possibility of preparing a complete ration by adding concentrates at the time of ensiling forages has considerable appeal from the standpoint of simplifying feeding. One of the infinite number of forage:concentrate combinations was evaluated by adding 23% digestible protein to 34% DM corn silage at the rate of 15% by fresh weight. The mixture was about 24% concentrate and 76% corn plant on a dry basis. This fortified silage was fed as the sole ration for 90 days to six cows averaging about 20 kg milk production. The ration fed to six control cows was untreated corn silage + 15% by weight of the same concentrate added at feeding time. The complete silage ration resulted in a significantly smaller daily milk decline rate. Dry matter intake, milk production and body weight gains were not significantly different.

These results indicate that the use of complete silage-based rations is feasible and should be explored further. Ensiling losses were a minor factor being 3% under these conditions. (03 31 030)

j. Improving the value of straw by ensiling. Low intake is recognized as the primary limiting factor in the feeding value of many low quality feeds such as straw. The possibility of improving intake of oat straw was tested by ensiling chopped baled straw with 0.9% formic acid and with hot water. The two silages were fed in comparison to chopped dry straw about five months later. Three heifers of about 240 kg were assigned to each feed for 12 days. Daily dry matter intakes of the chopped straw, hot water ensiled, and formic acid ensiled straw were .62, .72, and .94% of body weight. Although oat straw remained a low quality feed, the very limited results indicate the possibility of improving intake through formic acid ensiling. (03 31 030)

5. Dairy beef

a. Meat production from beef, dual-purpose and dairy steers. This study was conducted to study the relative merits of some beef and dairy cattle breeds and some different management systems in the production of beef. The period from six months of age (weaning) to slaughter has been analyzed. Steers were assigned to one of three ration groups. These were (1) all hay fed ad libitum; (2) all hay ad libitum until reaching 5/6 of their slaughter weight and then finished on all concentrates ad libitum; and (3) all concentrates ad libitum.

Average daily gain of steers finished on all concentrates, hay-concentrates and all hay was 2.2, 1.76, and 1.76; 1.98, 1.54, and 1.54; 1.76, 1.32, and 1.32; 1.32, 1.10, and 1.10 kg, respectively, for the Holsteins, Milking Shorthorns, Herefords and Jerseys. The corresponding efficiencies (kg gain/kg feed consumed) were 0.12, 0.08, and 0.08; 0.11, 0.08, and 0.07; 0.10, 0.08, and 0.07; and 0.08, 0.07, and 0.06, respectively. These differences

were significant for both breeds and rations. In addition, there was a significant breed x ration interaction effect.

The mean age at slaughter (days) for steers fed concentrates, hay concentrates and all hay was 518, 593 and 607; 578, 680 and 656; 554, 658 and 692; and 639, 656 and 714 days, respectively, for Holsteins, Milking Shorthorns, Herefords and Jerseys. These differences were also significant for both breeds and rations.

The mean dressing percentage (chilled carcass weight) varied for all breeds according to ration. Those fed all concentrates had a higher dressing percentage than those fed all hay and ranged from 60.7% for the Herefords to 53.9% for Jerseys. The Milking Shorthorns dressed out at 58.3% and the Holsteins at 56.3% on the all concentrate rations. The dressing percentages for the all hay rations were 52.4, 53.2, 55.4 and 48.8, respectively, for the Holsteins, Milking Shorthorn, Hereford and Jersey steers. Both breed and ration differences were significant. All steers fed out on the hay ration had a higher percentage of lean than those fed all concentrates. The Holstein steers produced the highest percentage of lean meat and lowest percentage of fat on each ration. They were followed by the Jerseys, Milking Shorthorns and Herefords. In addition, the Holstein steers had the largest rib-eye on all rations except all hay. In this category the Herefords excelled. The Jerseys ranked last.

This study shows that Holstein steers can make faster gains more efficiently and produce a higher percentage of lean meat than beef steers on all concentrate, hay concentrate or all hay rations. (03 31 057)

b. Meat from dairy and beef steers. Performance characteristics and carcass quality of Holstein and Hereford steers is being studied under a contract with the Wisconsin Agricultural Experiment Station. Steers are fed on either a high or medium energy ration and slaughtered at different body weights. In general, the average daily gains of the medium groups are about 70-80% of the corresponding high groups. Feed consumption per 100 lb. of gain appears to increase with size of animals and also to be higher for animals in the high energy group.

At body weights of from 500-1000 lb., Holsteins generally had a larger daily rate of gain and accomplished this on less hay and less grain than the Herefords.

Holsteins fed high energy rations and slaughtered at 750 lb. had a dressing percentage of 58 as compared to 61 for Herefords. Loin-eye area and carcass quality were in favor of the Herefords. The same general conclusions can be made from the slaughter data at weights of 1000 lb.

A group of Holstein steers were slaughtered at 1300 lb. - a weight estimated as physiologically comparable to Herefords slaughtered at 1000 lb. body weight. The dressing percentage, loin-eye area and carcass grade were very similar.

This study suggests that Holstein steers can produce acceptable meat. They gain faster than Herefords and have better feed efficiency. At slaughter weights up to 1000 lb. they yield carcasses with less quality than Herefords. When slaughtered at 1300 lb., carcass quality is very acceptable. (03 31 005)

6. Vitamin B₁₂

a. Vitamin B₁₂ synthesis in the rumen. The primary, if not the only, source of vitamin B₁₂ for the cow is synthesis by the microflora present in the rumen. Vitamin B₁₂ analogs, at least one possessing vitamin activity for the cow and others active only for microorganisms, are also produced there. Samples of rumen contents taken from cows fed various rations were examined by paper electrophoresis and paper chromatography, together with bioautography, using E. coli 113-3, to determine the various vitamin B₁₂ compounds present. The relative proportions of each were also estimated. The analog present in all the samples in the largest amount was 2-methyladenyl cobamide (Factor A). The average amount present in the samples from cows fed silage was 38%; in those from cows fed hay, 46%; and in those from cows fed a hay-grain mixture, 51%. Adenyl cobamide (pseudo-vitamin B₁₂) made up about 10% of the total B₁₂ activity in the samples from both silage-fed and hay-fed cows but less than 1% of the activity in the samples from the cows fed the hay-grain mixture. Cobinamide (Factor B) was present in the samples from silage-fed cows to the extent of 8% on the average but less than 1% occurred in the samples from cows on the hay or hay-grain rations. An unidentified electrophoretically slightly positive substance was present in all samples at about 8% on the average. Of the electrophoretically neutral material, 5, 6-dimethylbenzimidazolyl cobamide (vitamin B₁₂) made up on the average about 19 to 20% of the total activity, while another analog, probably the animal-active 5-hydroxybenzimidazolyl cobamide (vitamin B₁₂-factor III) contributed about 14%. Two other substances in the neutral fraction also occurred to an extent of about 1 or 2%. One of these may have been the analog designated by other workers as Factor E or I_b. Little, if any, differences were observed between the relative proportions of neutral analogs, adenyl cobamide, 2-methyladenyl cobamide and cobinamide that could be attributed to the time of sample collection after feeding, the position of collection in the rumen or the individual cow from which the sample was taken. However, as between two experiments carried out at different times and involving different samples of hay fed to the cows, the rumen samples taken from the cows fed hay in one experiment contained a larger proportion of adenyl cobamide than those taken from the cows fed hay in the other experiment (13 to 16% as compared to 1 to 2% on the average). Preliminary tests of cultures of pure strains of various species of functional rumen microorganisms, capable of producing vitamin B₁₂-active material, indicate that, even when cultured on the same media, the strains differ in the particular analogs they produce and the relative proportions in which they produce them. (03 31 054)

b. Vitamin B₁₂ and formic acid metabolism. Interpretation of previously conducted experiments on the role of vitamin B₁₂ in the metabolism

of formic acid (which is produced in the rumen of the cow and found there under certain conditions) was complicated by the growth-depressing action on rats of formate when incorporated in rations containing vitamin B₁₂. Attempts were made to elucidate the nature of this growth-depressing action. It was thought that there might be some disproportion between the amounts of folic acid and vitamin B₁₂ in the ration that might interfere with the metabolism of formate, with which both of these vitamins are concerned. However, neither reducing the level of vitamin B₁₂ nor raising the level of folic acid affected the results obtained. It seemed possible too that incorporation of formate into the ration might destroy one of the known vitamins. However, injecting vitamin B₁₂ or mixtures of the other B vitamins into the animals failed to prevent the growth depression with formate. Feeding a source of possible unidentified nutrients (dried whole liver) was also without effect. Inclusion of a flavoring agent (diacetyl) into the ration did not improve growth with formate. It seemed possible that the sodium in the salt used as the source of formate might be having a toxic effect on the animals. Replacement of the sodium salt by the calcium salt not only failed to prevent a growth depression but actually enhanced it considerably. Substitution of part of the sodium formate by potassium formate, so that the Na:K ratio remained the same as in the basal ration, had no effect. Thus, the origin of the growth depression encountered when formate was incorporated in vitamin B₁₂-containing rations remains undetermined.
(03 31 054)

c. Protein compounds of vitamin B₁₂ and its analogs. In nature, vitamin B₁₂ (cobalamin) and its analogs occur largely or altogether in the form of coenzymes complexed with proteins or polypeptides (corrinoid complexes). A considerable amount of information has been developed in regard to the chemical properties and biochemical function of these coenzymes. However, much remains to be learned about the constitution and mode of linkage of their apoenzymes and about the chemical and biological properties of the resulting holoenzymes. Work is underway to obtain basic information in these areas.

Propionibacterium shermanii 1 was selected as the source material for isolation of corrinoid-protein complexes, because of the ability of this microorganism to produce corrinoids in relatively large quantity. In culturing these organisms, 5, 6-dimethylbenzimidazole (the base of the nucleotide portion of vitamin B₁₂) was added to the medium to increase the yield of the vitamin. Two types of protein-corrinoid complexes were isolated from the harvested cells. Tests indicated that the corrinoid in each type was vitamin B₁₂. Both types were biologically active for the B₁₂ test organism, Escherichia coli 113-3. One, designated B₁₂-M, was obtained without the exclusion of daylight during procedures of isolation, purification and testing. The other, B₁₂-M-S, was obtained by carrying out these procedures in the dark or in dim red light.

The B₁₂-M-S complex was sensitive to daylight and upon exposure for 48 hours appeared to be converted to B₁₂-M. Comparison of the two types by paper

electrophoresis in the absence of daylight indicated that B₁₂-M-S contained two main fractions. One, constituting about one-fourth of the weight of the material, corresponded to the B₁₂-M complex. The color and absorption spectrum of the B₁₂-M-S were different from those of B₁₂-M and indicated the presence of coenzyme B₁₂ in the former complex. This finding was supported by the similar lability of B₁₂-M-S and of coenzyme B₁₂ toward light and cyanide. The corrinoid in B₁₂-M was presumably aquocobalamin.

The heterogeneity of the B₁₂-M-S complex was further evidenced by paper chromatography, tests on Sephadex columns and dialysis. Results of amino acid analysis indicated considerable differences between the two main fractions of B₁₂-M-S separated electrophoretically. The major fraction was characterized by a relatively high content of glutamic acid and the minor one (corresponding to B₁₂-M) by a high content of glycine; neither fraction showed the presence of cysteine or cystine.

The ratio of protein to corrinoid in the light-sensitive B₁₂-M-S was 1:4 to 1:8, depending upon the purity of the preparation. That of B₁₂-M was 1:1. From gel filtration studies, the molecular weight of B₁₂-M-S was estimated to range from 4000 to 8000. This value, considered together with the ability of a considerable proportion of the corrinoid-complex to dialyze, indicated that the complex possessed, at least in part, more the character of a polypeptide than of a protein.

In biological tests, addition of B₁₂-M-S complex to a cell-free extract of P. shermanii stimulated the methylation of homocysteine to produce methionine, a known function of certain cell-free B₁₂-enzyme systems.

No biologically active, light sensitive "protein"-corrinoid complex from P. shermanii had previously been isolated and characterized. (03 31 024)

7. Liberal feeding of concentrates as a means of higher production

a. Feeding level associations with conception. A PL 480 project in Israel is concerned with the relationships between feeding levels and reproductive performance. Two groups of 11 cows in their second or third lactation were fed 4 FU (Scandinavian feed units) roughage, and concentrates for maintenance. For milk production, concentrates were fed as follows: Group 1 received 1 FU for 2.5 kg. fat corrected milk and Group 2 was fed ad libitum for 100 days after calving. The number of services required and the number of days to conception were for Group 1, 4.00 and 203; and in Group 2, 1.27 and 82, respectively. Group 1 lost 40 kg. more weight than Group 2. There was a pronounced relationship between loss of body weight and lack of conception.

This study strongly suggests that cows should be fed at levels which will prevent rapid losses in body weight. (03 31 050)

C. Poultry

1. Nutritive requirements

a. Requirements of essential fatty acids. Several studies have indicated that the linoleic acid requirement of the hen for reproduction is approximately 1% of the diet or 0.38% of calories consumed.

The growing chick's requirement for linoleic acid has been difficult to estimate since a series of studies have yielded discordant results. The strains and breeds of chicks tested, the types of diets used, and the source of linoleic acid appear to be factors which influence the results.

Studies were conducted to compare the performance of linoleic acid deficient hens when they received equal quantities of an egg oil containing linoleic acid and another egg oil free of linoleic acid. Several dietary levels of the oil devoid of linoleic acid had no effect on the performance of the hen, and did not improve feed consumption over that of hens receiving no oil. Conversely, the birds receiving a 4% egg oil containing linoleic acid consumed about 25 gm. more feed per day than those receiving linoleic acid free oil, or those receiving no oil. In the absence of linoleic acid, the presence of fat calories in comparison with carbohydrate calories has no effect on performance. Therefore, linoleic acid seems to be a factor in controlling feed intake in the laying hen.

Another study was conducted to compare the performance of linoleic acid from two different sources. The growth of chicks receiving linoleic acid from egg oil was greater at all dietary levels than that with chicks receiving equal amounts of linoleic acid from safflower oil. The increased feed consumption by the chicks receiving the egg oil may account for their increased rate of growth. (03 29 017)

2. Digestion and metabolism

a. Utilization and function of vitamin A. Continuing studies with vitamin A at the Hebrew University, Rehovoth, Israel, have shown that storage of vitamin A in the liver was reduced by lowering the dietary protein level. The percentage of vitamin A found in the liver as retinol was also reduced. Plasma vitamin A and plasma protein contents were lowered to a great extent by protein restriction. Thyroxine supplementation of the diet increased both vitamin A storage and the percentage of vitamin A in the alcohol form. The extent of the changes caused by the thyroxine were dependent on the protein level in the diets. Thyroxine also lowered significantly plasma protein content.

In other studies the relationship between vitamin A level of plasma and the electrophoretic pattern of its proteins was investigated. Plasma vitamin A and plasma protein contents were significantly lowered in cockerels receiving a 5% protein diet. The drop in plasma protein level was caused by reduction

of the albumin fraction. No significant changes in levels of globulins were observed. When the dietary protein level was restored to normal, both the albumin and vitamin A levels in plasma increased.

Earlier studies showed that anhydroleutin is converted by the chicken to vitamin A₂. It was demonstrated by electroretinographic measurements that the spectral sensitivity of chickens fed anhydroleutin showed a distinct shift toward the red as compared with controls receiving vitamin A₁. (03 29 068)

b. Metabolism of calcium. Studies on the metabolism of calcium in the laying hen were continued at the National University, Rehovoth, Israel. Passage time of calcium through the digestive system was measured with the use of the isotope of the mineral Ca⁴⁵. The passage rate was highest in the duodenum and decreased progressively down the intestine. Outflow of Ca⁴⁵ from the intestine to the blood was rapid during the first 30 minutes after duodenal administration, after which time it slowed down considerably. The results indicate that the most effective site of calcium absorption is the jejunum.

In another investigation, dietary calcium levels of 4.5% and 3.5% were compared in diets containing varying energy levels. The higher level of calcium did not influence egg production, body weight or feed conversion. The high calcium level tended to depress feed intake on the high energy level. It also increased egg weight on high energy levels, but reduced egg weight on the low energy levels. (03 29 056)

c. Metabolism of fatty acids. In studies on the effect of essential fatty acid deficiency in laying hens, the fatty acid composition and weights of organs from normal hens and from hens severely depleted of linoleic acid were compared. The depleted hens had significantly lower body weights, smaller egg weight, lower production, depressed feed consumption, and high mortality. The fatty acid profile was indicative of an essential fatty acid deficiency in the lipids of all organs analyzed with the exception of the pituitary. The spleen, pituitary, pineal, thyroid and adrenals of the depleted hens weighed significantly more than corresponding organs from non-depleted hens. (03 29 017)

3. Nutritive value of feeds

a. Evaluation of protein quality and energy values. Studies were continued on the estimation of protein quality and energy content of indigenous feedstuffs at Punjab University, Ludhiana, India. The proximate composition, acid insoluble ash, calcium and phosphorus were determined for 20 feedstuffs. Metabolizable energy values were obtained for 12 feedstuffs. Tryptophan and methionine were determined for 34 feedstuffs and 39 feedstuffs were analyzed for lysine, arginine and histidine. In feeding trials, the nutritive values of ordinary versus deoiled rice polish were investigated. Tests on detoxification of guar meal indicated that cooking the meal in a moist atmosphere partially destroys the toxic principle. (03 29 050)

b. Effects of feeding cottonseed meal. Tests at Glendale in cooperation with the University of Arizona indicated the yolk discoloration in cold stored eggs caused by gossypol was prevented to a great extent by the addition of ferrous sulfate to the diets of laying hens. None of the nine meals obtained from various sources at 5 and 10% dietary levels with 0.1% ferrous sulfate produced discoloration in eggs cold stored for three months. After six month's storage there was a pink coloration in the eggs.

In another study at Glendale in cooperation with the University of Arizona, the results show that pink whites are obtained on storage when relatively large amounts of methyl dihydrosterculate (a cyclopropane fatty acid derivative) are fed to laying hens. Whether the eggs turn pink because of the compound itself or its metabolic products has not been determined.

In studies at Glendale in cooperation with the University of Arizona, dietary levels of free gossypol as high as 0.03% did not cause significant mortality in chicks. Ruptured glands of cottonseed had no effect on growth at any of the levels fed, but raw seeds depressed growth at higher levels. The pure gossypol was the most toxic of any of the sources fed since it depressed growth at all levels. (03 29 015)

In a study to compare the nutritive values of cereal grains in laying diets, corn, wheat, oats and barley were fed with diets containing 10, 12.5 and 15% protein. The results for the combined protein levels showed a significant decrease in egg production in the following order: oats, corn, wheat, barley. As the protein level was increased, egg production and body weight increased independently of the grain fed. Mortality was lower on the highest protein level, and feed conversion was greatest on lowest protein level. Oats produced the largest body weight gain, had a lower mortality than wheat, and showed a higher feed conversion than wheat or barley.

4. Selection for increased egg production under subcircadian periodicities. In the fourth generation the selected lines showed an advantage of 8.1 and 6.2 percentage points over the controls for the 18- and 24-hour populations, respectively. Since the randombred controls were slightly above normal in the 24-hour population and slightly below normal in the 18-hour population, the genetic progress was essentially identical under the two environments. Realized heritability estimates varied considerably over generations with an average estimate of .21 in the 24-hour population and .18 in the 18-hour population. Heritability estimates based on dam's component of variance were much higher, .59 and .47 for the 18- and 24-hour populations, respectively. The egg production curve of the 18-hour population suggests that it may be beneficial in subsequent "short day" studies to increase the photoperiod length during the growing period and/or laying period to hasten sexual maturity. (03 29 004)

5. Genetic aspects of the ability of chickens to utilize amino acids.

Processing of data collected under this project has continued. Early results show that only a portion of the differences in body weight at three weeks brought about by selection is realized at maturity. In other words, there is some but not complete compensation of differences in growth, measured on a percentage of body weight basis, from three weeks to maturity. Selection for high or low three week body weight on adequate or methionine deficient diets seems to have little or no effect on subsequent egg production. A theoretical discussion of some of the problems inherent in selecting for altered specific nutrient requirements and possible ways of alleviating these problems was published. (03 29 005)

6. Biochemical genetics. Lines of Japanese quail are being used to provide information on growth rate inheritance. One of these lines has been selected on an adequate diet (P line); the other line on a protein-deficient, thiouracil containing (T line) diet. The third has been maintained as a randombred control line (C line).

Protein accretion rates of the three lines were estimated by carcass analysis of quail at biweekly intervals from hatching to eight weeks of age. Few among-line differences were noted with respect to percentage composition of protein, fat, water and residue. When the data were compared on an absolute basis, however, both selected lines contained more of each constituent than the control line. The protein accretion rate was maximal during the second to the fourth week for all lines. During this period, quail of the C line synthesized 9.46 g. of protein, those of the T line 9.54 g. and those of the P line 10.49 g. In general, T line quail grew and accrued protein at rates intermediate to the P and C line quail.

The thyroid activity of the three lines of quail was measured after five generations of selection. A goiter-prevention assay, conducted with quail from the second to the fourth week posthatching, provided an estimate of the thyroid secretion rate of 1.62 mcg. thyroxine/100 g. body weight/day for quail of all lines. No significant among-line differences were noted. A dose response experiment, in which quail of the three lines were challenged with increasing amounts of dietary thiouracil was also conducted. Body weights and liver succinoxidase activities decreased and thyroid weights increased as the dietary concentration of thiouracil increased. The diet-line interaction for four week body weight approached significance, suggesting a differential line response to the dietary thiouracil.

A separate group of experiments served to assess the protein requirement and feed efficiency of the three lines. Using a conventional growth assay based on four week body weight, the protein requirement of the P and T lines was estimated to be 26%. The corresponding value for the C line was 20%. The lines ranked (from best to poorest) P, T, C with respect to weight gain, and T, C, P with respect to feed efficiency throughout the growing period. (03 29 007)

D. Sheep and Fur Animals

1. Sheep

a. Feeding pellets to sheep. Four years of observations have been completed on sheep that have received (1) limited amounts of alfalfa pellets, (2) limited amounts of a concentrate and chopped hay mixture, (3) alfalfa hay pellets ad libitum, and (4) a concentrate and chopped hay mixture ad libitum. Each group contained 15 animals at the start. Number of animals and average weight of animals, per group, on July 20, 1967, were (1) 12 and 106.4 kg.; (2) 11 and 104.5 kg.; (3) 13 and 115.6 kg.; and (4) 11 and 110.2 kg. (03 33 009)

b. Studies on nutritive requirements of sheep. Studies on energy requirements for body weight maintenance of sheep were continued at Beltsville, Maryland. Comparisons were made on 14 head of wethers over a two year period. Average body weight during the year ending in 1966 was 48.09 kg. and 48.18 kg. for the last year. Maintenance requirements were 49.89 g. air dry alfalfa pellets/day/wt. kg. 0.75 for the first year and 49.77 for the second. Differences between sheep within years were highly significant. The coefficient of variation attributable to between sheep effects was 6.4%. (03 33 011)

c. Relation of body size to feed efficiency. Cooperative research, with Cornell University, was initiated in late 1966 to study the effect of parental size on the nutritional efficiency of lamb production. Sixty head of ewes of varying body weights were bred to rams of either larger or smaller size. Ewes and their lambs are being fed in individual pens. Feed intake records plus slaughter data on the lambs will provide data for determination of the relationship between parental size and efficiency of lamb production. (03 33 023)

d. Effect of different levels of feed intake of lambs on lifetime lamb and wool production. Over a six year period, 2,810 individual ewe lambing records were obtained at Dubois, Idaho. The final average winter feedlot weights of the ewes as lambs were 100, 120 and 140 lb. for low, intermediate and high levels of feed intake. The influence of these final winter feedlot weights on subsequent lamb and wool production is being investigated. The average lifetime grease wool production (six years) was 10.8, 11.2 and 11.5 for low, intermediate and high levels of feed intake as lambs, respectively. Most of the advantage in wool production of the intermediate and high feed level ewes resulted from large differences in the yearling fleece. Birth weights of lambs were not significantly affected by feed treatment. Percent of lambs born of ewes lambing was 138 (low), 139 (intermediate), and 142 (high). Percent of lambs weaned of ewes lambing was 105 (low), 104 (intermediate), and 106 (high). Pounds of lamb weaned per ewes lambing was 82 (low), 80 (intermediate), and 81 (high). These data show that there is no advantage in feeding replacement ewe lambs to a high degree of condition during their first winter in the feedlot. The

increased wool production does not compensate for the increased feed costs. In addition, there appears to be no advantage under the conditions of this investigation to feed ewe lambs at higher levels to increase lamb production. (03 33 014)

e. Nitrogen metabolism in sheep. Effects of a range of dietary protein levels from a single source, on nitrogen metabolism of sheep, were studied in Israel. The protein was a mixture of Rhodes grass hay and raw soybean meal. Rumen alpha-amino acid levels were affected most by level of protein and ammonia levels least. Addition of cornstarch to a basal diet containing either alfalfa or soybean meal protein increased protein utilization. The effect of starch on protein utilization appears to depend on the dietary protein level. Free alpha-amino acid and short chain peptide amino acid levels have been found to vary considerably depending on the dietary protein source.. (03 33 021)

2. Energy and protein requirements of goats. Energy and protein requirements of goats for growth, reproduction and milk production have been studied in India. Different planes of nutrition during gestation significantly affected the birth weight of kids from a dual purpose breed, but did not affect the birth weight of kids from a dairy breed. Feeding the highest level of both energy and protein (125% of Morrison's recommendations for sheep) during gestation of the dual purpose breed resulted in the largest kids. Data also indicate that high and medium levels of energy (125% and 100% of Morrison's requirements for sheep) are essential for the best reproductive performance and milk yield of both types of goats. Adult bucks can be maintained on 75% of Morrison's recommended allowance of TDN and digestible crude protein for sheep. (03 34 011)

3. Fur Animals

a. Development of mink diets based on sea fish and sea mammals. Conflicting results at Petersburg, Alaska, on high fish vs. fish plus meat and the use of the antioxidant BHT during the reproductive period indicated a need to check previous work and afforded an opportunity to further compare iron fumerate and iron sulfate for the prevention of cotton fur.

Both the iron compounds successfully prevented the cotton fur abnormality. No cotton skins were produced on the diets containing either of these products. Production was better in the four groups receiving the antioxidant and one of the iron supplements than in either unsupplemented group; animals on the three diets containing seal meat weaned 15% more young than those on the all-fish diets.

The antioxidant prevented steatitis and the seal meat had some effect on the prevention of this malady. Animals pelted from the unsupplemented diet containing seal meat did not show any symptoms of steatitis, whereas eight of the 44 animals pelted from the similar all-fish diet showed various degrees of the malady. Weaning weights were satisfactory on all six diets

and the animals on the high fish unsupplemented diet weighed less and had poorer quality pelts than those in the other five groups at pelting time. The two supplemented high fish diets produced slightly larger and equal or better quality pelts than the diets containing the 15% seal meat. (03 34 006)

b. Feeding crab waste to mink. The immense amount of king crab waste available in Alaska prompted a study at Petersburg, Alaska, to evaluate the possible use of this product in the diet of ranch mink during the growing and furring out period (summer and fall months).

The waste contained the carapaces, blood, viscera and tails of king crab manufactured into a dry meal. It was fed at levels of 0, 3, 6 and 10%, replacing a like amount of fur seal meat in otherwise similar high fish diets. Average weights were lower in direct proportion to the amount of crab meal received. The group receiving 10% were definitely smaller than desired for this type of mink, although they consumed the most food.

Using pelt value as a criterion of quality, the animals receiving 3% crab meal produced the best pelts. The average difference of one to two dollars between the male pelts of this group and those of the other three was of definite significance. Results of this trial indicated that a level of up to 5% of this waste product could be recommended depending on other diet ingredients. (03 34 006)

c. Feeding shrimp waste to mink. Shrimp waste, consisting of small shrimp and large shrimp, less the meat in the tail section, was ground, frozen and fed to female mink at Petersburg, Alaska. Comparisons when fed with flounder and with halibut indicated reproductive rates similar to those with the fish, plus crab meal. All lots weaned an average of four kits per female. (03 34 006)

d. Development of dry diets for mink. The development of dry diets (diets containing no fresh animal products) for mink may bring about a 30 to 50% decrease in the cost of feeding mink. During the first reproductive season at Ithaca, New York, 14 females were fed a regular diet of meat, fish, liver, cottage cheese, cooked eggs and a dry mix which had been freeze-dried at 30° C. for 48 hours at an atmospheric pressure of from 100 to 200 microns of mercury, and then reconstituted with water and fed in a manner similar to the regular diet. These mink were started in January and fed through the breeding, gestation, lactation and early kit growth. These 14 females had 53 kits at weaning (42 days) which averaged 300 grams in weight, for an average of 3.52 kits per female. This production and kit growth approaches normal. Thus, it can be considered that the normal mink diet freeze-dried and reconstituted will support breeding, gestation, whelping and lactation.

In a second study, 20 female dark mink were fed a diet made up of high quality dried ingredients consisting of dried cooked eggs, dried potatoes, soybean meal, fish meal, distillers solubles, wheat germ meal, fat and

vitamins. Of these 20 females, only one whelped, and her kits were dead before the end of 24 hours. The cause for this reproductive failure is unknown. The diet is currently being fed to rats to determine the effect on reproductive performance. (03 34 007)

e. The vitamin B₆ requirement of the growing mink. A study to determine the vitamin B₆ requirement of growing mink and to investigate the intermediary metabolism of this vitamin in the mink was continued at Ithaca, New York. Seventy-five pastel male mink were used in a growth trial using purified diets containing 0, 0.4, 0.8, 1.6 and 3.2 mg. of vitamin B₆ per kg. of diet. Mink receiving the three lower levels showed deficiency symptoms. The group receiving 0.8 mg. per kg. diet, however, showed growth comparable to the higher groups, but only nine animals out of the 15 survived at 20 weeks of age. Forty male mink were used in two metabolism studies. Xanthurenic acid excretion preceding and following the ingestion of 2.5 mmoles L-tryptophan was measured by a colorimetric procedure, and kynurenic acid and N¹-methylnicotinamide were also measured under the same conditions by fluormetric procedures. Sharp elevations in the excretion of xanthurenic acid and kynurenic acid were observed following the injection of L-tryptophan when the mink were in the state of vitamin B₆ depletion. These values returned to predepletion levels following supplementation with 1.6 or 3.2 mg. of vitamin B₆ per kg. of diet, dropped slightly following supplementation with 0.8 mg. per kg., and remained high when 0 or 0.4 mg. of vitamin B₆ per kg. of diet was fed. The conclusion was drawn that the minimum requirement of vitamin B₆ to support life, promote growth, and prevent the abnormal metabolism of tryptophan was 1.6 mg. (pyridoxine hydrochloride) per kg. of diet. (03 34 007)

f. The niacin deficiency on growing mink and a study of its ability to convert tryptophan to niacin. Two studies of the effects of niacin deficiency upon growing mink were conducted during the summer of 1966 at Ithaca, New York, using purified diets. The first of these was conducted upon two groups of 16 kits each to determine the effects of niacin deficiency when the kits were four to six weeks of age, just prior to weaning. The control group received a purified diet containing niacin at a level of 40 milligrams per kilogram of diet. The treated group received a purified diet deficient in niacin. All mink in the group receiving the purified diet deficient in niacin died within two weeks after the initiation of the experiment, while the controls gained an average of 72 grams. The gross deficiency symptoms were loss of weight, loss of appetite, weakness, incoordination of hind legs, weak voice, and bloody stools. There were no observable eye, mouth or anus lesions. Samples were also collected for histological examination.

The second study contained 45 dark mink receiving three different purified diets. The control received a purified diet containing niacin at a level of 40 milligrams per kilogram of diet. The deficient group received a purified diet deficient in niacin, and a third group received a niacin deficient diet to which DL-tryptophan was added at a level of 1.6 grams

per kg. of diet. The experiment was initiated on July 9 by mixing gradually increasing amounts of purified diets with the ranch diet and the mink were receiving the completely purified diets by July 21. By August 12, over half of the group receiving the deficient diet were dead and by August 13, over half of the group receiving the deficient plus tryptophan were dead, compared to none dead for the controls. On August 15, the control group was split and one-half of the mink received the niacin deficient diet plus DL-tryptophan at 3.2 grams per kg. of diet. All of these mink died within four weeks after starting on this diet. This study conclusively demonstrates that mink are not able to convert dietary tryptophan to niacin. (03 34 007)

g. Feeding of foxes. Feeding of unconsumed mink feed to a small herd of blue and white foxes at Petersburg, Alaska, has shown that these reproduce and thrive on diets composed of various amounts of a great many different fish and shell fish products available in Alaska even after such ingredients have been exposed to warm summer temperatures for at least 24 hours. Breeding and reproduction in 1967 were the best ever obtained at this Station with an average of eight pups weaned per litter. (03 34 002)

E. Swine

1. Metabolic utilization of feed and the effect on carcass composition. Pigs from lines selected for maximum and minimum backfat within the Yorkshire and Duroc breeds were used to measure the effect of difference in type on response to nutritional variables. Previous work was concerned with the effect of a 25% reduction in daily gross energy intake on the growth and development of these pigs. Currently a comparison of the effect of 12 and 20% levels of dietary protein is being studied. Preliminary results indicate that the high and low fat lines differ in their response to the variation in protein levels. Data on carcass composition obtained by slaughtering at ages ranging from 12 to 32 weeks show that both low Yorkshire and low Duroc pigs tended to accumulate more lean tissue during this period when they were fed the 20% protein diet than when they were fed the 12% one. There was little dietary effect on the amount of carcass fat in these two lines. The high fat lines did not respond to the added protein. The amount of lean tissue in the carcasses was essentially the same on both diets suggesting that the protein increment above 12% was not used by the high fat pigs in the synthesis of lean tissue but was used simply as an energy source. (03 32 020)

2. Toxic effects of cottonseed meal. Hearts from 17 animals that showed evidence of gossypol poisoning during two cottonseed toxicity trials and from seven animals fed typical corn-soybean diets were studied. Muscles of the septum and left and right ventricles of swine hearts were analyzed for sodium and potassium content to investigate the possibility that electrolyte balance in this organ might be altered by gossypol ingestion. The ratio of potassium to sodium in right and left ventricles and septums of normal animals was 2.55, 3.18 and 2.96, respectively; for the gossypol animals, the ratio was 2.68, 2.86 and 2.92. The average potassium content

of the right and left ventricles and septums from normal animals was 2,651, 3,208 and 2,990 ppm, respectively. Potassium values for like tissues from pigs showing evidence of gossypol toxicity were 2,987, 3,086 and 3,122 ppm, respectively. Sodium values for the same tissues from normal and gossypol-fed pigs were 1,041, 1,009, 1,009 and 1,115, 1,079 and 1,070, respectively. There was no significant difference in the total amount of potassium and sodium or their ratio in the heart muscles studied between control pigs or those fed gossypol. (03 32 021)

3. Protein metabolism in monogastric animals connected with their requirements for essential limited amino acids. (PL 480) Six typical diets differing in sources and levels of amino acids are being evaluated with growing pigs and broilers in order to select the three most adequate ones for further study. A diet based on animal protein sources has given the best growth response followed by one containing a mixture of plant proteins. The supplementation of sunflower meal with methionine and lysine gave better results than the addition of methionine alone to soybean meal.

The first intake of colostrum by newborn pigs caused a large increase in the concentration of the amino acids in blood plasma that are most abundant in colostrum (leucine, proline, tyrosine, and phenylalanine). Although colostrum is relatively low in isoleucine and methionine, the plasma levels of these two amino acids also increased sharply after colostrum ingestion. This indicates that quantitative changes in the plasma amino acid pool reflect the amino acid composition of colostrum to only a limited degree. Studies on changes in the plasma amino acids pattern of young pigs on a starvation regimen and of growing pigs in relation to levels of dietary amino acids are in progress. (03 32 028)

F. Broadly Based

1. The mechanism of lactation and its augmentation by hypothalamic stimulation. A working hypothesis was developed for the mechanism of lactation based upon studies with hypothalamic depressing lactogenic drugs. Depression of the hypothalamus with tranquilizers results in a release of a prolactin releasing factor (PRF), the consequent release of prolactin from the pituitary and lactation in the mammary gland. Stereotaxic electrical stimulation studies were undertaken to localize the site of the PRF in the rat hypothalamus. Stereotaxic map coordinates were established for the stimulatory area of the hypothalamus which produced maximal development of the mammary gland.

Hydrocortisone, the adrenal cortical hormone, was found to considerably increase the lactogenic effects of the hypothalamic depressant drug, perphenazine, in both intact and adrenalectomized rats. Studies in normal and pinealectomized rats indicated that the pineal body does not inhibit the hypothalamic release of prolactin from the pituitary. The role of the thyroid in hypothalamic lactation was also evaluated. Propylthiouracil,

an antithyroid compound, stimulated mammary gland growth but inhibited milk secretion in both postpartum and perphenazine-induced hypothalamic lactation. Treatment with triiodothyronine counteracted this suppression of milk yield. These results suggested that thyroid hormones at physiological levels interfere with mammary gland development in its preparatory stage but that they are essential for the later stages of milk secretion. (03 98 001)

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AREA NO. 312. ENVIRONMENTAL STRESS IN PRODUCTION OF LIVESTOCK AND POULTRY

Problem. The total investment in farm buildings in 1964, excluding operator dwellings, was estimated at \$14.6 billion. Most of these facilities are for livestock, but, in spite of this large investment, stresses from the effects of climate, handling, and other environmental causes decrease productivity. Reducing these effects could result in net benefits of \$418 million annually by 1980. Extremes in temperature, humidity, and air movement lead to poor feed efficiency, throw animals off feed, reduce resistance to disease, and in extreme cases cause death losses.

USDA AND COOPERATIVE PROGRAM

The USDA and cooperative program in this area is rather limited. The effort in beef cattle includes studies on the effect of climate on growth rate and feeding patterns. Dairy cattle research involves crossbreeding to increase adaptability to climatic conditions of the Gulf Coast region and measurement of surface and respiratory evaporation in domestic animals.

A basic and applied program of research directed toward the reduction of losses from broiler condemnations is conducted jointly by specialists in agricultural engineering, animal diseases, poultry management, biochemistry, and physiology. Two locations are involved in this work, the Southeast Poultry Research Laboratory, Athens, Georgia, and the South Central Poultry Research Laboratory, State College, Mississippi. The Animal Husbandry Research Division's work at Athens emphasizes physiology in relation to the chronic respiratory disease complex and the work at State College emphasizes environment, management, physiology, and nutrition in relation to condemnation losses.

This research program is cooperative with the Animal Disease and Parasite and Agricultural Engineering Research Divisions, ARS. Local cooperation of State experiment stations and the broiler industry in the Southeast and South Central regions is an important part of the program.

Sheep research involves a limited cooperative program on the environmental factors affecting growth and development.

Public Law 480 research in progress includes a study of the effect of environmental stresses on *Tribolium* conducted at the Institute Nacional de Investigaciones Agronomicas, Madrid, Spain.

The total Federal scientific effort in this area is 7.6 SMY intramural and 1.9 SMY extramural distributed as follows: beef cattle, 0.7 SMY intramural and 0.3 SMY extramural; dairy cattle, 1.3 SMY intramural and 1.6 SMY extra-

mural; poultry, 4.4 SMY intramural; and sheep and fur animals, 1.2 SMY intramural.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State stations in this area totals 64.3 SMY which are distributed as follows: beef, 8.2; dairy, 8.2; poultry, 25.4; sheep and other animals, 8.7; swine, 8.7; and cross species, 5.1.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Beef Cattle

Preliminary observations indicate that steer feeding patterns are equally influenced by light from the red, green and blue portions of the visible light spectrum. (03 30 026)

B. Dairy Cattle

1. Crossbreeding to increase adaptability. In cooperation with the Louisiana Agricultural Experiment Station, a study is underway to determine the feasibility of increasing adaptability to the Gulf Coast region by crossbreeding. Crossbred cows by Holstein and Brown Swiss sires had lower milk and solids-not-fat yields than purebred Holsteins, but crosses strongly excelled in fat yield. Protein production was the same for these crosses and purebreds. Value of product was slightly higher for crossbreds sired by Brown Swiss and Holstein bulls.

Animals sired by crossbred bulls were inferior to Holstein contemporaries for all production traits.

Analyses of reproductive performance showed little difference between crossbreds and contemporary Holsteins. However, crosses by Holstein bulls had significantly fewer days open from calving to conception than those sired by Brown Swiss bulls. Data indicated that as milk yield increased within breed, fertility decreased. (03 31 016 2)

2. A method for continuous direct measurement of surface and respiratory evaporation in domestic animals. Studies were continued on a system to determine total surface and respiratory evaporation rates and CO₂ combining power of the blood simultaneously. A cow was placed in a hygrometric tent (10' x 5' x 3') and evaporation rates were computed from the difference in intake and exhaust dewpoints and the volume of air flow through the tent. Respiratory evaporation and CO₂ production were measured separately using a muzzle mask and duct apparatus. The system was calibrated by evaporating a known weight of water within the tent. When calibrated daily maximum error was $\pm 2.2\%$. Average evaporation rate from a Holstein cow was 100 gm/m²/hr. at 35°C and 17 mm Hg vapor pressure, which compares favorably with various methods used by other workers. Respiratory evaporation rates averaged 13.2

gm/m²/hr which was exceptionally low. Further work showed the large dead space in the muzzle mask and duct apparatus primarily responsible for the low values. The dead space also made calculation of CO₂ combining capacity of blood impossible, since an accurate alveolar CO₂ level could not be determined.

A hygrometric tent (4' x 3' x 2') was used for determining surface evaporation in sheep. A similar tent (2' x 3' x 2') was placed over the head of the sheep. This eliminated the dead space and created a more natural atmosphere. When calibrated daily maximum error was $\pm 2.0\%$.

Nine rams (3 unshorn, 3 medium length fleece, 3 completely shorn), 3 wethers and 3 ewes were tested at various temperatures and humidities to determine effect of fleece length, sex, and adaptation on surface and respiratory evaporative losses. A computer program was designed to calculate the evaporative losses, since there were many variables to be considered and dewpoints were taken at the rate of 90 per hour per dewprobe. Analysis of the data is underway. (03 31 015)

C. Poultry

1. Hormones and blood chemistry. A daily blood sample was obtained from six-week-old Athens Randombred (ARB) chickens over a five-day period during which they received intramuscular injections of gelatin, cortisol or ACTH. Plasma corticosterone and cholesterol concentrations reached maximal levels in the hormone injected birds by the third day, then plateaued. Plasma calcium was significantly increased by 0.5 mg of cortisol per 1100 g of body weight/day after one day of administration but was not appreciably influenced by the other treatments. As expected, the packed cell volume (hematocrit) of all birds which were bled each day was depressed compared to controls bled only on the last day, however, there was a significant depression of hematocrit in the cortisol-treated birds below those of the bled controls. (03 29 043)

2. Mechanisms of adrenal hormone production. In a series of experiments to explore fundamental mechanisms of adrenal hormone production in chickens, freshly extirpated glands of nine-week-old ARB chickens were incubated in an enriched Krebs-Ringer bicarbonate media containing ACTH with or without NADPH (reduced diphosphopyridine nucleotide). After extraction and chemical separation, analyses by Thin-Layer Chromatography and Gas-Liquid Chromatography showed that corticosterone and aldosterone concentrations were significantly increased by the addition of NADPH, while cholesterol concentrations were greatly reduced. Cortisol and cortisone levels remained essentially unchanged. This indicated that steroid synthesis and metabolism in the avian adrenal are essentially the same as in the mammal although percentage concentrations of the individual steroids differ considerably. (03 29 043)

3. Temperature effects on broiler chicks. A preliminary experiment has been completed using environmental cabinets in which the wall, ceiling and

floor temperatures can be controlled independently of the air temperature. When air and wall temperatures were cycled together from 35° to 105°F and returned over a 24-hour period, body weight gains of broiler chicks from four to eight weeks of age were significantly depressed when compared to chicks maintained in cabinets with constant air and wall temperatures (70°F), cycling air and constant wall or cycling wall and constant air. Blood samples taken during the moderate portion of the temperature cycle (70°F) from birds in the cycling environment indicated that the blood pH was lower and the sodium and chloride ions of the plasma were reduced compared to the more constant environment. (03 29 043)

4. Feed stress. In a comparison in the climatic chambers, rations were used differing primarily in energy (110 lbs. per ton of poultry oil and 20 lbs. of 50% soybean meal replaced 120 lbs. of yellow corn meal). Broilers were brooded starting at 85°F and the temperature reduced to 82°, 74° and 60°F by week until the end of the fourth week. The second four weeks, the broilers were under fluctuating diurnal temperature between 41° and 71°F. Under these temperatures, which are below the optimum conditions for feed efficiency, there was not a significant difference in feed efficiency (or gain) between rations, although the feed efficiency of the high energy ration was slightly lower than that for the low energy ration. At the same time, in a more conventional type broiler house and under normal brooding temperatures for late April and early May, there was a significant difference in feed efficiency (and gain) between the same two high and low energy rations. Under the stress conditions in the climatic chamber, the pounds of feed required per pound of gain for combined sexes was 2.54 for the high and 2.67 for the low energy ration. The corresponding figures for the warmer brooding conditions were 2.18 and 2.34. Under the stress of cold, the broilers apparently used protein for energy and consumed more feed to keep warm. Poorer feed efficiency resulted. Further work is in progress.

The addition of protein above the usual requirement, by replacing yellow corn meal with 50 and 100 pounds of feathermeal, depressed feed efficiency in broilers. The depression was offset by adjusting the calorie to protein ratio with added poultry oil. Further work is in progress. (03 29 044)

5. Temperature stress. Studies in a windowless unit, made by modifying an existing poultry house, indicate that a rather close control of humidity and ventilating rate is necessary to control dust and ammonia. Bird density drastically affects dust and ammonia in a house. Results to date indicate that direct control of the ventilating rate by exhaust dewpoint temperature has advantages over relative humidity-temperature systems.

It was found that broilers exposed to five weeks of age to relatively short-term temperature extremes can withstand relatively severe temperature extremes. This was true whether the chicks were from flocks tested negative to the S-6 strain of PPLO (M. gallisepticum) or had been infected with PPLO. When the chicks are brooded for the first three weeks in temperatures of 60°F or below, mortality increased significantly. The parameters measured in

addition to mortality, were condemnation and eight-week body weight.

In the climatic chambers, chicks grown from the fifth through the eighth week under a fluctuating diurnal temperature between 40° and 80°F had a slightly higher condemnation rate than chicks grown at a constant temperature of 60°F. Otherwise, there was very little difference in the performance of the broilers grown under these two temperature schedules. Chicks brooded at a temperature starting at 85° and reduced to 80°, 70° and 60°F by the end of the fourth week performed as well as chicks brooded starting at 95°F and with the temperature reduced to 90°, 80° and 70°F by the end of the fourth week. No hovers were used.

In 16 bird chamber studies, there were no significant differences in body weight gain, feed conversion or condemnation for air exchange rates ranging from an average of 0.05 cubic feet per minute (cfm)/bird for a 12-hour period and 1.0 cfm/bird for the next 12-hour period, up to 3.0 cfm/bird. There were some indications that lower ventilation rates produced lower body weights.

A warmer winter temperature and a cooler summer temperature can be maintained in broiler houses that are insulated. Condemnations were not less in the insulated houses. Dust may be a problem in insulated houses and may offset the improved temperature and drier litter conditions. (03 29 044)

6. Density effect. Temperature is a factor in density effects on body weight gain of broilers. Four experiments were conducted. In the first three experiments 3% of the chicks from flocks tested negative to the S-6 strain of PPLO (M. gallisepticum) were injected intranasally with pathogenic M. gallisepticum egg yolk material at one day of age. Contrary to general belief, when broilers are reared in temperatures above approximately 70°F the density effect is reduced or eliminated when comparing 0.7 and 1.0 square foot per bird. When birds are brooded in temperatures below approximately 70°F, birds reared at 1.0 square foot per bird are significantly heavier than birds reared at 0.7 square foot per bird.

Preliminary studies have confirmed sex differences in uric acid content of the serum and a decrease in the blood serum albumen/globulin ratio in broilers showing positive immunological reaction with M. gallisepticum. (03 29 044)

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AREA NO. 313. IMPROVED LIVESTOCK AND POULTRY PRODUCTION MANAGEMENT SYSTEMS

Problem. Livestock production is projected to involve cash receipts of \$28 billion in 1980. Within-firm management involves the efficient use of labor, feed, equipment, capital and animals themselves in producing animal products. Coordination among the various sectors of an industry is essential; e.g., in the broiler industry the breeder flocks, hatcheries, feed mills, growout operations and processing plants must be meshed into a smoothly functioning system. It means using biological and economic data to develop an optimum and complete production-management system. Potential savings could exceed \$3.4 billion annually, with 25% of these achievable by 1980.

USDA AND COOPERATIVE PROGRAM

Breeds and breeding systems

A. Beef cattle

Most beef cattle breeding research in the United States is a cooperative, integrated effort of State experiment stations and the USDA. This report includes results of both Federal and State stations participating in the research. Where results relate specifically to a problem area such as reproduction or feed efficiency, they have been included with other results in these areas.

The regional project in the South is S-10, Improvement of Beef Cattle for the Southern Region Through Breeding Methods. Much of this region is subtropical in climate and in many cases cattle used in other areas are poorly adapted. Environmental conditions adversely affecting survival, reproductive regularity and growth are encountered. Research includes projects at 13 State stations and at the USDA Stations at Jeanerette, La., Front Royal, Va., and Brooksville, Florida.

In the Western Region the beef industry is largely geared to range conditions, with many cattle shipped to areas of abundant grain supply for fattening. Ability to make maximum use of forage available on the range is an important consideration. These problems are studied through regional project W-1, The Improvement of Beef Cattle Through the Application of Breeding Methods. Research includes projects at 12 State stations and at the USDA Station at Miles City, Montana.

Similarly, NC-1, Improvement of Beef Cattle Through Breeding Methods, is geared to problems of the beef industry in the North Central Region where beef is produced on farms with pastures of high productivity and ample grain supplies for feedlot finishing. Research includes projects at 12 State

stations and at the USDA Stations at Fort Robinson, Nebraska, and Fort Reno, Oklahoma.

B. Dairy cattle

This is a continuing program of basic and applied research aimed at improving the performance of dairy cattle through genetics and management. Research in breeding includes studies of breed performance, breeding systems, genetic parameters, genetic appraisals of cows and sires, genetics of milk and blood constituents, genetic-environment interactions, and population genetics. Management research includes studies aimed at decreasing production costs through improved herd and farm management practices, with emphasis on optimizing the use of feeds and forages, breeding animals, labor, facilities and other resources available to farmers.

These studies are in progress at Beltsville, Maryland, and cooperatively with experiment stations in 9 States and in laboratories in 24 foreign countries. Several studies contribute to the North Central and Southern regional dairy cattle breeding projects. Cooperative efforts include the National Association of Animal Breeders and the national dairy breed associations.

C. Poultry

This is a continuing long-term program of fundamental and applied studies on the improvement of meat and egg production in poultry. Scientists with majors in genetics, cytology or biochemistry and minors in statistics or physiology conduct this research. Much of the research is conducted within the framework of four regional projects. In addition to major contributions to the establishment and maintenance of central facilities, the USDA also provides coordinating personnel at Athens, Georgia, and Lafayette, Indiana. The close working relationship between the USDA and State experiment stations in the four regional projects provides for integrated research on a large scale without duplication of effort.

Research at Beltsville, Maryland, involves the following studies: selection for a nutritional deficiency and the effect of such selection on egg production; the biochemical basis for differences in such lines; selection for response in egg production to "18-hour" days in cooperation with AERD; the biochemistry of mutant hemoglobin types in the fowl; and cytological bases for parthenogenesis and interspecies crosses in birds.

The North Central Region is concerned with the improvement of egg production through studies of different selection methods and mating systems. The work is conducted at the North Central Regional Poultry Breeding Laboratory, Lafayette, Indiana, and at eight cooperating State experiment stations. In the Southern Region the emphasis is divided between egg and broiler traits and the work, involving genotype x environment interactions is conducted at the Southern Regional Poultry Genetics Laboratory, Athens, Georgia, and at eight cooperating State experiment stations. Cooperative work in the

Northeastern Region involves the improvement of chickens through genetic and physiological studies and is conducted at eight cooperating State experiment stations.

D. Sheep and fur animals

This is a continuing program conducted by geneticists and animal husbandmen on basic and applied studies of breeding to increase efficiency of production of high quality lamb meat, wool and fur. Work in progress at Beltsville, Maryland, involves breed comparisons, studies of gains resulting from crosses of breeds, and selection for increased lamb production. Selection studies are involved in cooperation with a private ranch in Utah. A study of effect of breed on lambing twice yearly is conducted at Fort Reno, Oklahoma, in cooperation with the Oklahoma State Agricultural Experiment Station. At Dubois, Idaho, systems of mating are compared including development and crossing of inbred lines and selected strains. Also studies on heritability and other genetic parameters of economic traits, as well as studies on improved methods of selection are conducted. Cooperation is maintained with 15 State experiment stations and with the Western, Southern and North Central Regional sheep breeding projects. Breeding research with fur animals was conducted at Petersburg, Alaska, and Madison, Wisconsin, in cooperation with the Alaska and Wisconsin State Agricultural Experiment Stations.

There is one grant involving PL 480 funds in a foreign country on goat breeding. A project at the University of Ankara, Ankara, Turkey, on estimation of genetic parameters in Angora goats is supported for five years (1967-72) by \$27,900 equivalent in Turkish liras.

E. Swine

This is a continuing program of basic and applied research conducted by geneticists and animal husbandmen to elucidate genetic principles and develop effective breeding systems that will result in further increases in the efficiency of swine with respect to productivity and carcass value. This is a coordinated research effort involving the USDA and several State agricultural experiment stations. Research is in progress at Beltsville, Maryland, cooperatively with the Montana Agricultural Experiment Station at Miles City, Montana, and at the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa. The Regional Laboratory includes cooperative projects at State Agricultural Experiment Stations in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Ohio, Oklahoma, South Dakota, and Wisconsin. Investigations on genetic principles, selection, and breeding systems include work with swine and also with laboratory animals on important performance traits, their heritabilities, and their phenotypic and genetic correlations. The results of such studies provide the basis for emphasis given to different complex traits and the underlying factors in evaluating different systems for achieving genetic changes. Traits of major interest include productivity of dam, viability, growth rate,

feed efficiency, carcass composition, and quality of meat.

There is also a research contract with Purdue University to study the effect of different types of housing on fly control.

Cooperative research with the Food and Drug Administration is in progress to investigate the response of "miniature" swine to further reduction in body size from selection and their usefulness for toxological tests, as well as basic studies in nutrition and genetics.

A grant to the College of Agriculture, Poznan, Poland, provides for investigations on red blood cell and serum antigens to establish the mode of inheritance and relative frequencies of these antigens in certain breeds of swine. Its duration is for five years (1962-67) and involves PL 480 funds of \$4,111 per year.

F. Broadly based

Research in this area involves the two pioneering genetics laboratories. The emphasis in one is on basic population genetics of animals. In the other, blood antigens and antibodies are emphasized.

Systems of production management

A. Beef cattle

The research is carried on at Beltsville, Maryland; Fort Reno, Oklahoma; and in cooperation with State experiment stations in Georgia and South Dakota. This research relates largely to feeding sequences. A contract with the Wisconsin Agricultural Experiment Station on feeding sequences for producing beef from dairy stock is part of the program.

B. Dairy cattle

The research in dairy involves investigations to support the DHIA program. Included is research on weighing, sampling and testing procedures.

C. Poultry

The work in poultry involves participation in the random sample performance testing program conducted by the States. Data from the United States and Canadian tests are collected, summarized and published in a combined summary.

D. Sheep and fur animals

This is a continuing program conducted by biochemists, nutritionists and animal husbandmen involving development of production practices to increase efficiency of production. Producers need better methods of animal manage-

ment for the reduction of lamb mortality, procedures for handling sheep on pastures and ranges, supplemental feeding and management of sheep during breeding, gestation and lactation, as well as other labor saving procedures and devices for the routine handling of sheep and fur animals. Research is conducted at Dubois, Idaho, in cooperation with the Idaho and Utah State Agricultural Experiment Stations, with the Forest Service, and at Beltsville, Maryland. Cooperation is maintained with the Western Regional Project W-46 on environmental stresses affecting range cattle and sheep.

E. Swine

Specific management practices and complete management systems to reduce structure costs per unit of output are being studied at Purdue University, Lafayette, Indiana.

The Federal effort under Area No. 313 by AH is 27.2 SMY intramural and 2.3 SMY extramural distributed as follows: beef cattle, 3.8 SMY intramural and 1.7 SMY extramural; dairy cattle, 8.4 SMY intramural; poultry, 4.4 SMY intramural, (NPIP not included); sheep and fur animals, 3.4 SMY intramural and 0.1 SMY extramural; swine 4.2 SMY intramural and 0.5 SMY extramural; and broadly based, 3.0 SMY intramural.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State stations in this area totals 74.8 SMY which are distributed as follows: beef, 21.0; dairy, 19.0; poultry, 18.2; sheep and other animals, 5.4; swine, 9.9; and cross species 1.3.

PROGRESS -- USDA AND COOPERATIVE PROGRAM

Breeds and breeding systems

A. Beef cattle

1. Heterosis in beef production. Heterosis is being studied in breed crosses and in crosses of inbred lines of the same breeds. In most experiments there have been relatively small but positive heterotic responses for calf crop born, for calf survival to weaning, and for growth to weaning weight in first crosses. Cumulatively, the heterotic effects are large enough to increase pounds of calf weaned per cow bred by 5 to 20% in different sutes as compared to averages of the pure breeds or lines used in the crosses. Heterosis for postweaning growth has been small but positive. Carcass traits have not exhibited heterosis. Over all, results indicate advantages from crossbreeding great enough to warrant its consideration by commercial cattlemen. (03 30 003); (03 30 005); (03 30 006); (03 30 011); (03 30 008); (03 30 020); (03 30 022); (03 30 024); Ohio NC-1 contributing projects; and Alabama, Florida and Louisiana S-10 contributing projects.

Preliminary results of second phases of several of these experiments comparing maternal qualities of straightbred and crossbred females indicate additional heterosis in percent calf crop weaned or growth rate of calves to weaning.

For the first four years (1963-66) of one experiment, the advantage of crossbred cows has been 17, 6, 10 and 3%, respectively, for calf crop weaned and 17, 31, 20 and 22 pounds, respectively, in average weaning weight. (03 30 022)

Four years of results from a Virginia experiment (total of 475 matings) show that average calf birth dates were February 15 and February 18; average calf percentages born were 94.9% and 93.7%; average calf percentages weaned were 89.4% and 89.0%; average calf weaning weights were 442 lb. and 423 lb., respectively, for crossbred and straightbred dams in each case. When slaughtered after a postweaning feeding period, carcasses of both steers and heifers from crossbred dams were heavier. (03 30 003)

In one study combining breeds in such a manner as to utilize discriminately the advantages of each breed and at once to create hybrid vigor has been developed as an efficient breeding system resulting in calves approaching 1,000 lb. at 365 days. This system, especially with developmental adjustments and improvements, compounds the economic advantages of both gainability and hybrid vigor so that very substantial improvement of production efficiency results. (03 30 015)

Recent studies offer convincing evidence that there are high levels of hybrid vigor exhibited in bull semen characteristics and in viability of newborn calves. The structure or morphology of sperm cells is greatly affected by inbreeding and hybridizing with the linecross bulls showing 26.5% heterosis over the inbreds in semen morphology score. The percent heterosis on other semen scores were 4.3% in concentration, 9.5% in vigor, and 7.4% in percent alive. In contrast, heritability estimates were predominantly low for semen characteristics being .14 for semen quality, .37 for concentration, .13 for vigor, .06 for percent alive, and -.06 for morphology. Heterosis was evident in the reduction of death losses among calves. The four groups, consisting of inbreds, linecrosses, controls and crossbreds, showed 13.98, 7.46, 11.79 and 9.26% dying, respectively. The death losses among linecrosses relative to controls decreased from 11.79% to 7.46%, a reduction of 37%. (03 30 005)

2. Heritabilities of economic characters and genetic relationships.

Estimates of genetic parameters are subject to large sampling errors, so additional data are desirable. During the year one study gave estimates of .43 and .47 for heritability of birth weight in Angus and Herefords, respectively, in a population of 1,514 calves. Genetic correlations between birth and weaning weight were -.22 and +.68 for the two breeds.

Heritabilities were estimated from data on 152 steers and bulls fed for 211 and 253 days postweaning. Estimates were .43 for average daily gain (adjusted for average slaughter age), .43 for pounds of TDN consumed (adjusted for average slaughter age), .36 for Warner-Bratzler shear values, .41 for marbling, .0 for fat thickness, .10 for kidney and pelvic fat, .01 for pounds of retail product and .20 for Longissimus dorsi area. (03 30 022)

In North Carolina studies on 210-day weight and average daily gain to weaning had relatively low heritabilities when estimated by both paternal half-sib and dam-offspring relationships. Gestation length was moderately heritable by both methods, but birth weight heritability was considerably higher when estimated by paternal half-sib correlations. Genetic correlations between the four traits were all positive and ranged from about .30 to about 1.00. Knowledge of resemblances of (1) paternal half-sib families, (2) maternal half-sib families, (3) maternal grand sire families, and (4) dam-offspring relationships were used in establishing sets of simultaneous equations to estimate maternal and environmental parameters associated with four traits. For each of the traits the additively genetic maternal component was very large indicating that maternal influences are important sources of influence on these traits. The covariance between the genetic value for a trait and the genetic value for the maternal influence on the trait was negative for all of the traits studied. This is suggestive of an inherent buffering mechanism operating to maintain an optimum for a trait rather than allowing the accumulation of extensive deviations in either direction. Nonmaternal environmental variances were small for birth weight and gestation length and relatively large for 210-day weight and average daily gain.

The covariance between the genetic values of the maternal components for birth weight and gestation was negative. This negative relationship implies that a maternal genotype which favors a heavier birth weight would be associated with a maternal genotype favoring a shorter gestation length. This would be beneficial in selection schemes emphasizing birth weight but where no increase in gestation length was desired. (03'30 007)

3. Effectiveness of selection for traits of economic importance.

Several selection experiments involving closed lines being selected for various single traits or indexes are being conducted. Criteria of selection includes measures of growth rate, efficiency, conformation and carcass merit. For the most part, these projects have not been in progress long enough to establish direct response and correlated response in other economic traits to the selection pressure applied to date. In one experiment, foundation sires and their selected sons have sired calves in the same year. The selected sons produced progeny that were generally superior to the progeny of their sires in the primary selection criteria. These experiments are continuing with sires selected in subsequent years being compared by contemporary progeny to sires selected in earlier years. (03 30 022) Michigan, Missouri and Illinois NC-1 contributing projects.

In a Nevada study, data have been studied from ten years of single trait selection in five closed lines for rate of gain, efficiency of gain and

conformation at one location and for rate of gain and efficiency of gain at another. During the period of approximately two generations, no clear-cut divergence of lines has become apparent. Bulls from the gain and efficiency lines have produced somewhat leaner carcasses than those from the conformation line. (03 30 010)

Preliminary summaries of data from a Front Royal, Virginia, study in which lines of Shorthorn and Angus cattle were subjected to single trait selection for rate of growth and for conformation score indicate the lines are diverging in the direction of selection in both breeds. (03 30 019)

At Miles City, Montana, frozen semen stored for several years was used to compare the performance of contemporary progeny of sires born in 1953-55 with that of sires born in the same closed line in 1961-63. Calf numbers were small, but averages favored the progeny of bulls born in the second period in birth and weaning weights and weaning score.

4. Inbreeding, linecrossing and use of inbreds in top crosses. The performance of some closed, mildly inbred lines in topcross evaluations when compared to outbred stocks indicates that within-line selection has been effective in improving traits with an appreciable amount of additive genetic variation. (03 30 020)

5. Genetic-environmental interactions. An Ohio experiment has included Hereford, Charolais and reciprocal crossbred calves by the same sires. One-half of the calves were creep-fed, fattened immediately following weaning and slaughtered at slightly over 14 months of age. The other half were not creep-fed, were wintered, grazed for about 60 days, fattened in dry lot and slaughtered at about 20 months of age.

There were significant breed-management interactions in weight of edible portion produced per day of age and in marbling scores. Charolais calves produced more edible portion per day of age than Hereford calves but this difference was greater when they were creep-fed and fed out at 14 months of age than when they were managed by the deferred system. Hereford and crossbred calves slaughtered at the younger age had higher marbling scores than those on the deferred system, while the opposite was true with the Charolais calves. (Ohio NC-1 contributing project.)

Seventy-seven steer and 75 bull Angus calves by 15 sires were fed a ration containing 68.4% TDN from weaning to 211 days and 253 days after weaning in an experiment designed to investigate sex by slaughter date, sire by slaughter date and sex by sire interactions for certain production and carcass traits. Sire by sex interactions were not significant for adjusted 200-day weaning weight or postweaning average daily gain. A significant sire by sex interaction was detected for pounds of TDN consumed/day and a correlation of only .28 was observed between the two sexes among the 15 sire progeny groups suggesting that bulls and steers by the same sire respond differently for appetite.

Interactions were not significant for pounds of retail product, pounds of trimmed retail product, carcass weight 1. Dorsi area or pounds of kidney and pelvic fat. A significant sex by sire interaction was detected for Warner-Bratzler shear values but most of this was due to differential variances in the two sexes. The correlation between performance of the same sire groups in the two sexes was considered high enough (.56) that no difficulties should be encountered in assessing value of sires in selection programs.

The interaction of sires with slaughter data approached significance ($P < .10$) for average fat thickness over the twelfth rib, indicating that sires may differ in the amount of fat deposited by their progeny between the two slaughter dates. The interaction of sex with slaughter date was significant for marbling score. Bulls apparently increased in marbling between the early and late slaughter dates at a slower rate than steers. In view of the large number of interactions tested and the general lack of significance, the significant interactions may not be meaningful. (03 30 022)

Six calf crops have been weaned in a cooperative project at Miles City, Montana, and Brooksville, Florida, in which sample halves of herds of cattle developed at each location were transferred to the other. To date performance has favored the cattle retained at a location as compared to those transferred from the other. Thus, the suggestion is strong, but still tentative, that previous selection for performance at each location had resulted in some selection for adaptation to the environment. (93 30 012)

6. Performance testing. Birth and weaning weight data obtained on 1,514 Hereford and Angus calves in the Fort Reno breeding project since 1950 were used to examine some sources of variation associated with birth weight. Male calves were 4.10 lb. heavier in the Angus and 5.85 lb. heavier in the Hereford herd than female calves. Birth weights showed small but significant association with age of dam and date of birth also.

Records from 914 Hereford and 459 Angus calves from the Fort Reno Livestock Research Station were used in a study to determine the influence of day of birth on adjusted weaning weight of beef calves.

It was concluded that the percentage of variation in adjusted weaning weight associated with day of birth effect is small and dependent on the year the calf was born. Adjustments for the association of adjusted weaning weight and day of birth effect common to all years would be of little value. Under most conditions, present adjustment procedures for weaning weight of a calf would be adequate without further adjustment for day of birth.

Records of 13,937 Hereford and Angus calves recorded in the Oklahoma Beef Cattle Improvement Program were used to examine the effects of age of dam, sex, breed, type of pasture, month of birth and creep-feeding and their two way interactions on weaning weight. The results indicated that the effects of age of dam were essentially the same regardless of sex, breed, type of pasture, season of birth, or type of management (creep vs. no creep). Sex

by type of management, month of birth by type of pasture and month of birth by type of management interactions were significant and appear important enough to be taken into account in adjusting weaning weights. The same data were used to study whether additive or multiplicative adjustment factors would be most appropriate for adjusting weaning weights for the effects of age of dam, sex, season of birth and type of management. Additive corrections were found to be more appropriate than multiplicative corrections in adjusting for the effects of age of dam, season of birth and type of management since they more nearly equalized the variances within subclass groups. Multiplicative corrections were found to be more appropriate in adjusting for the effect of sex. In addition to more nearly equalizing variances within sexes, multiplicative corrections completely accounted for the interaction observed between sex and type of management. (03 30 006)

7. Breed comparisons. Characterization of production characters of average animals of different breeds is difficult due to lack of knowledge on whether animals studied are truly representative of their respective breeds. However, results of studies in which efforts have been made to systematically sample breeds and combinations of data from several stations appear to permit some generalizations. Among the British breeds, Angus appear to grow more rapidly to weaning, Herefords have greater postweaning rate of gain and Angus greater carcass marbling. The Charolais and Brown Swiss breeds and their crosses exhibit greater pre- and postweaning gains than British breeds and produce leaner carcasses at given slaughter weights (from many studies).

In specific S-10 studies involving several herds, weight-age curves have been found to be relatively inflexible creating correlations among rates of gain and weights at different ages or stages of maturity. Individuals within breeds follow a more or less characteristic pattern for that breed. Angus cows were found to mature earlier than Hereford cows. Also, weight and age of dam tended to account for similar sources of variation in progeny gains (substantiating earlier work on this project) but the ratio of average daily gain per unit of dam weight was negatively related to dam weight in each herd.

Data from three experimental herds in Alabama, Georgia and Texas were included in another cooperative S-10 Southern Regional Study. Preweaning records of 1,616 Angus and Hereford calves and postweaning feedlot data from 1,052 individuals, from dams 2 to 12 years of age, were analyzed to evaluate their relation to postpartum weight of dam. Preweaning ADG of calves from dams that had raised all of their progeny was less than ADG of calves from dams of lesser fecundity. Also, dams that had raised all of their calves to weaning weighed less than cows that had not raised all of their progeny. Angus calves gained most rapidly from dams averaging 570 kg. whereas preweaning ADG of Hereford calves was maximum when dams averaged 600 kg. The relationship between preweaning ADG and dam weight was more curvilinear among Herefords. The effect of fecundity of dam on postweaning ADG tended to be inversely related to its influence on preweaning ADG. Postweaning ADG was positively but not significantly related to weight of dam. Partial linear regressions of postweaning ADG on dam weight were 0.03 and 0.02 kg. per 100 kg.

increment in dam weight, respectively, for Angus and Hereford calves.
(03 30 015)

In a crossbreeding study at Miles City, Montana, evaluations of the Charolais, Angus and Hereford breeds as sires and as dams have been made. In general, the Charolais breed was the growthiest of the three breeds as represented in this study. Within the Charolais breed, the Charolais produced heavier calves at birth when functioning as breed of sire than when functioning as breed of dam. Conversely, the Charolais as breed of dam produced faster gaining and heavier weaning calves, but differences were significant only when based on performance of male progeny. Calves from Charolais dams scored somewhat higher at weaning than did calves by Charolais sires.

Calves from Hereford dams were heavier at birth than calves by Hereford sires. Male calves by Angus sires scored higher than male calves by Angus dams. With these exceptions, each of the British breeds performed similarly as breed of sire and as breed of dam. (03 30 015)

8. Biochemical and cytological variants. A study to determine genetic polymorphism of hemoglobin and transferrin types of beef cattle and the relationship of these traits to birth weight, yearling weight, average daily gain, and total gain on test was conducted using 232 purebred heifers and cows and 168 crossbreds at three Texas stations. Frequencies of the A and B hemoglobin alleles based on the observed phenotypes were 84.5% and 14.5%, respectively. Angus were found to have only the A allele and the frequency of the A allele in Herefords and Brahmans was 98.9% and 46.5%, respectively. Hemoglobin types were not significantly related to any of the production data studied. Angus and Herefords showed more transferrin heterozygotes than would be expected from the Hardy-Weinberg distribution, but the difference was not statistically significant. When breed effects were removed there was no significant association between transferrin type and any of the quantitative traits studied.

Variant milk proteins from individual cows were isolated. Significant variations of amino acid content from that reported on analogous proteins of dairy animals was found. This study is continuing and it is hoped that a simple and rapid technique for the detection of inherited milk protein variants can be developed.

Bisexuality in domestic cattle is dependent upon an established chromosomal system in which the two sexes differ in regard to the morphology of a single pair of chromosomes -- the X and Y. In Bos taurus the centromere of the X chromosome is submedially located and is one of the largest chromosomes of the karyotype. The Y chromosome also has a submedial centromere, but is one of the smallest chromosomes in the karyotype. The Y chromosome of Bos indicus (Brahman or Zebu) differs morphologically from the Y chromosome of Bos taurus in that the centromere is telocentric and cannot be distinguished from the autosomes on the basis of shape. Females of both species have morphologically similar X chromosomes. Species origin of sires of males

resulting from reciprocal crosses between Brahman and breeds of European descent was determined on the basis of Y chromosomes and the possible effect on fertility poses interesting questions about which presently only speculation can be made.

Whole blood cultures from a one-month-old Brahman male calf were treated with tritiated thymidine during the latter part of the DNA synthesis period. The control cultures had an average of 0.37 broken chromosomes per cell, whereas the treated culture had an average of 3.70 broken chromosomes per cell. The chromosomal damage sustained due to the influence of β radiation was much greater than that reported for chromosomes of other species when treated similarly. In general, more of the large chromosomes of the karyotype were damaged than the small chromosomes. The X chromosome was damaged in only 13 of the 106 cells examined. These observations may indicate differential replication patterns of large vs. small, autosomal vs. sex chromosomes. (03 30 015)

Heritability estimates have been made of hepatic carotene, hepatic vitamin A, blood hemoglobin level, and plasma carotene, vitamin A and phosphorus levels in unsupplemented range Hereford cattle in Arizona at weaning, 12, 20 and 24 months of age. Heritabilities range from low to high and vary with season and sex. Implications of these genetic variations as related to production efficiency are not known. (03 30 017)

Preliminary Oregon studies show differences between closed lines in pituitary gonadotropic hormone content and suggest higher levels for linecrosses. Liver nicotinamide nucleotide coenzymes were positively correlated with age at 1,000 lb. live weight and with percent carcass fat. Linecross animals tended to have lower coenzyme levels, higher rates of gain and leaner carcasses as compared to inbreds. (Oregon contributing W-1 project)

In Arkansas, analysis of data on a "founder-like" foot anomaly suggested a genetic basis. Higher blood calcium levels, calcium deposits in testicles and kidneys, and atrophy of the parathyroids were associated with the defect. (Arkansas contributing S-10 project)

B. Dairy Cattle

1. DHIA program

a. Performance testing. A review of recent trends and report of the current status of performance testing in farm livestock and poultry was completed. Growth of performance testing has been rapid in all species in the last decade, and it has at least doubled in the percentage of the Nation's animals involved for most species. In 1966, 21% of the Nation's dairy cows were enrolled in production testing as compared to 9.6% in 1956. About half of the States are operating on-the-farm swine performance testing, a program which only started about 1950. Random sample testing of poultry strains for egg production is now widespread and appears established in the industry.

Beef testing programs now record over one-half million cows annually.

Among the more important developments of recent years are electronic processing of performance data and especially in dairy cattle, on-the-farm and central-station testing of swine and beef cattle, and large-scale random sample comparisons of the egg producing ability of poultry strains. Evidence indicates performance testing will continue to increase. (03 31 040)

b. Sire evaluation program. During the past year, procedures for genetic evaluations of sires were revised and updated, incorporating recent technical advances in biometrical methodology, data processing and research results. Major changes included the computation of estimated transmitting ability for every bull by taking into account number of daughters, records, herds and distribution of progeny across herds; use of age adjustment factors that account for differences due to region, season, milk and butterfat, and breed; more rapid dissemination of results to the dairy industry via direct computer printing and adaptation of data processing to a new and more widely used computer system.

As part of the revision, updated genetic evaluations were recomputed on the 62,000 bulls having sufficient progeny with herdmates in existing master files.

A total of 1,625,509 DHIA records of performance were reported during the year and were used along with the existing master files in producing 9,627 individual genetic appraisals of bulls having progeny in recent years during the three regular production runs. (03 31 039)

c. A comparison of alternative sire evaluation procedures. Three procedures for assessing progeny test results were compared: herdmate comparisons, least squares, and maximum likelihood. Employing data for 40 bulls used artificially in Michigan, it was found that herdmate comparisons and least squares ranked bulls essentially identically but maximum-likelihood estimates were seriously biased. Since the rank correlations between herdmate and least squares proofs were approximately 0.95, the more complex least squares method apparently offers no major advantage. Factors such as incorrect repeatability and nonrandom use of sires across herds were investigated as possible sources of error in the maximum likelihood estimates. A comparison of non-AI sire to artificial-service sires indicated an average advantage of about 170 lb. of milk and 8 lb. of fat for artificial service. (03 31 039)

d. Survey of application of artificial insemination in the United States. A survey of research and practical applications of artificial insemination in the United States was conducted for FAO. Artificial insemination in dairy cattle has increased at an essentially linear rate, reaching 48% of the population in 1966. Indications are that AI service is beginning to have a very favorable impact on the genetic merit of dairy cattle. Recent estimates have indicated up to a 200 lb. average

superiority in milk for progeny of AI bulls. Applications in other species of livestock have been limited by such factors as the cost of service, lack of frozen semen techniques, difficulty in heat detection or estrus control and opposition by pedigree associations. (03 31 041)

e. Cow evaluation program. Genetic appraisals of registered cows in DHIA herds were made and the resulting indices of breeding merit were made available to the industry. Approximately 280,000 cows were indexed and data on the best two percent were published and distributed. This information provides dairymen and artificial insemination personnel with the identity and location of superior cows which may be used to produce bulls for future use in artificial service. Research was conducted to derive improved procedures to more accurately account for distributions of paternal half-sibs over herds and to obtain a criterion of accuracy of the cow index. (03 31 039)

f. DHIA testing intervals. DHIA and actual milk yields based on daily weights of 639 lactations in the Beltsville herd were compared to determine errors in DHIA records. DHIA estimates were within $\pm 5\%$ of the actual records 95% of the time. However, the magnitude of errors was about twice as large as expected from the day-to-day variation in daily milk yields.

A review of 39 investigations comparing the accuracy of DHIA-type records and actual milk yields was also completed. The consensus was that lactation yields based on monthly testing are adequate for almost all purposes, and that bimonthly or trimonthly testing is adequate for ranking cows and identifying poor producers within herds. (03 31 040)

g. Adjustment of lactation records for age. A review of 41 research investigations in five countries showed that age adjustment factors vary by season of calving, milk and milk fat yield, and breed of cow. Studies in three countries have also shown differences in adjustment factors among different geographical regions within individual nations.

Differences between the yields of young and older cows were less in summer than in winter; therefore, age adjustment factors were lower for cows calving in the summer. Milk fat yield varied less than milk production between young and mature cows, and accordingly needs lower factors. The major influence on variance in factors for geographical areas appears to be level of mature yield, since this varies much more among areas than first-lactation production.

These concepts were utilized in developing a revised set of age adjustment factors. (03 31 040)

h. A comparison of alternative age corrections. Two different sets of multiplicative age adjustment factors were compared empirically; one which took season, region and yield trait into account and one which used the same percentage corrections throughout. It was found that bulls ranked the same on first lactation progeny records, irrespective of age correction.

Age factors stratified by seasons magnified the degree of seasonal variance in age adjusted records. It appeared that neither set of age corrections were very effective in removing variation associated with age. No evidence was found for heterogeneity in age-production relationships from year to year. It was concluded that general sets of age factors may fail to fit individual subsamples very well. Research applications requiring age adjustment should consider other methods of age correction, such as regression. (03 31 040)

i. Age variation in part-lactation records. Part-lactation data for 39,328 Holstein lactations were studied to obtain factors for converting monthly test records to a mature basis. It was found that the factors should take into account season of freshening since the age curves were flatter in the summer season (July-September) than in other seasons. Stage of lactation was also an important variable; the increase in yield from two years of age to maturity was much less for the later portion of the lactation than for the earlier months. Factors for milk yield were found to be larger than those for fat yield. In addition, interactions of season and stage of lactation and stage of lactation and yield trait (milk or fat) were found to be important. It was concluded that age factors must simultaneously consider stage of lactation, season and yield trait. (03 31 040)

j. Effect of environmental correlations on sire evaluation. The theoretical correlation between paternal half-sibs resulting from their number and distribution over herds was derived. Empirical verification was obtained by studies with the progeny of 277 widely sampled Holstein bulls. Both the theoretical and empirical results showed that repeatability of sire evaluations drops in a predictable manner each time a daughter is not in a separate herd. Estimates of the residual correlation in lactations expressed as deviations from herdmates were obtained, and methodology developed so that it would be possible to compute estimated breeding values on all bulls evaluated through DHIA progeny.

This study provides for a more effective sire proving program by adjusting sire evaluations for the distribution of daughters across herds. (03 31 039)

2. Evaluation of mating systems and crossbreeding

a. Selection for high milk production using various mating systems. At Beltsville, production responses were analyzed for the effects of mating systems consisting of closed herd, outcross and crossbred groups. Selection for increased milk yields have been effective. Increases from first to second generation females have been +1,408, +1,130 and +594 lb. of milk for the closed herd, outcross and crossbred groups, respectively. Statistical analysis indicated significant effects of mating systems, years, years within mating system, generations and generations within mating system. Variation between animals sired by Brown Swiss bulls was much larger than the variance of other groups. There was a significant between year effect for all cows. Actual 2X 305 day first lactation averages were 12,023, 11,722 and 10,946 for

the linebred, outcross and crossbred groups, respectively.

This study indicates that rapid progress can be realized by selection for milk production using good progeny proven bulls. It also shows that a faster rate of progress can be made using bulls of the Holstein breed than bulls of other breeds. Opportunity for sire selection within the Holstein breed more than offsets any benefit derived from heterosis. (03 31 010)

b. The influence of parental relationships on the genetic merit of dairy cows and sires. A study was initiated to determine the rate and efficiency of gain of female progeny resulting from a breeding project designed to evaluate the relative merits of three systems of mating; closed herd, outcrossing and crossbreeding. The feeding system employed consisted of a pelleted ration containing 75% by weight of alfalfa hay and 25% by weight of concentrates fed at the rate of 2.0 lb. per 100 lb. of body weight daily to heifers from each of the mating system groups for 120 days between 12 and 16 months of age. Results showed a mean daily rate of gain of 1.60, 1.53, 1.70, 1.59 and 1.55, respectively, for 54 outcrosses, 54 closed herd, 19 Swiss crosses, 14 Ayrshire crosses and 19 backcrosses. The corresponding efficiency of gain (lbs. of gain/therm of feed) was 0.152, 0.150, 0.163, 0.156 and 0.148. A one-way analysis of variance was computed. There were no significant differences among groups in either daily rate of gain or feed efficiency. These results suggest that differences in gain are primarily a result of appetite differences and not efficiency of feed utilization. However, gross observation of the sire groups within outcross mating systems reveals a range in the rate of gain from 1.27 to 1.73 lb./day with a corresponding range in efficiency of 0.12 to 0.17. The sire groups within closed herd systems ranged from 1.43 to 1.73 lb./day and 0.14 to 0.16 for efficiency. The range is not as pronounced in the crossbred group since fewer sires are represented.

This study suggests that selection could be practiced within breeds to increase feed efficiency and rate of gain. (03 31 009)

c. Crossbreeding dairy cows. Preliminary comparisons were made among Ayrshires, Brown Swiss, Holsteins and their crosses. Crossbreds containing one-fourth to one-half Holstein inheritance exceeded the average of their parent purebreds for yield traits (milk, fat, and protein) by 5% to 17%, and by 4% to 9% in feed efficiency. Heterosis was greater in first lactation income over feed cost and ranged from 9% to 32% superiority for crosses having one-fourth to one-half Holstein inheritance over the average of their purebred parents. Crossbred calves had fewer cases of disease and infection (5% to 41%) than expected from the performance of their parental purebreds, and a greater percentage survived and completed one lactation. Results indicate that all traits of economic importance must be considered in evaluation of crossbreeding in dairy cattle, and that results can be evaluated only in terms of specific crosses. (03 31 041)

d. Crossbreeding effects on production and size. Analysis of data

at Illinois was concerned with heterosis effects and the relationship between weights and measures and milk production. For milk production and size, it appears that the additive genetic differences between and within the Holstein and Guernsey breeds are larger than the nonadditive genetic effects resulting from crossbreeding; thus, for genetically changing these two traits, it appears that a dairyman should use a breeding system which exploits additive genetic variance. It was found that the accuracy of predicting subsequent milk production from body weights and measurements differed among the various breed groups. The data suggests that in the smaller breed groups production may be more closely related to weight and size. (03 31 008)

e. Rate of milking studies (breeding herd). A continuous flow rate Kymograph was used to record the maximum rate of flow (pounds per minute), duration of maximum rate of flow, yield during the maximum rate, total yield and total milking time for one PM milking during three stages of the first lactation (30 ± 15 days, 150 ± 15 days and 270 ± 15 days). Cows representing the outcross, closed herd, and crossbred mating system groups were used in this study.

In summary the outcrosses had the highest maximum rate of flow during all three stages of the lactation, followed by the closed herd, backcrosses, Ayrshire crosses and Swiss crosses. Both the backcrosses and Swiss crosses appeared to have a slight advantage over the other groups in the length of time milking at the maximum rate. In most instances, there was a definite relationship between the maximum rate of flow and level of production. The faster rates occurred during the early stage of lactation (30 ± 15 days) for all groups with the exception of the S x H crosses. The rates for this group were 5.7, 7.4 and 9.0 lb. per minute, respectively, at 30 ± 15 , 150 ± 15 and 270 ± 15 days. The corresponding total yields were 17.8, 15.4 and 15.0 lb. The reason for these results are not entirely clear at this time. There were no real differences in total milking time between the outcrosses, closed herd or Ayrshire crosses at any of the three stages of the lactation. However, both the backcrosses and Swiss crosses had longer milking times.

This study indicates genetic differences among the various breeds of dairy cattle in their milking characteristics. High rates of milking are generally associated with larger volumes. (03 31 009)

f. Female losses associated with systems of breeding. Data were summarized at Wisconsin on all causes of disposals of heifers in a cooperative herd. A total of 745 calves were born of which 127 (17%) were removed from the herd before first parturition. Fifty-one percent of the losses occurred between birth and ten days of age. One-fourth of early calfhood losses was due to pneumonia, scours and other digestive troubles. Comparisons of disposal rates between systems of mating showed rates of 28% for the inbred group, 18% for the outbred group and 14% for the linecross group. Differences between sire lines within mating systems, interaction between sire lines and systems of mating were not significant. The effect of degree of inbreeding on disposal rate showed that rates increase with degree of

inbreeding. For inbreeding coefficients of 0% to 12%, 13% to 25%, 26% to 33%, and 34% to 42% death losses were 18%, 24%, 30% and 37%, respectively.

The greater losses between birth and first calving indicate that the development and maintenance of inbred lines for crossing is too expensive to recommend this system of mating to dairy farmers. (03 31 006)

g. Crossbreeding effects among dual purpose animals. In cooperation with Purdue University a study was completed which involved crosses among Red Dane, Milking Shorthorn and Red Poll cattle. The percentage of heterosis observed for body weight, body measurements and lactation traits are all quite low. Some of the body weight and measurement traits showed a statistically significant effect due to crossbreeding. None of the production traits showed significant effects. These data indicate that the additive genetic variance is much more important than the nonadditive genetic variance. Consequently, selection between and within breeds is a more potent means of improving dairy cattle than is crossbreeding. Rather clear-cut evidence has been presented to indicate that crossbreeding will be of value only when the breeds crossed are near the same mean level of performance. Selection of the breeds to be crossed and the individuals of a breed is more important than the actual crossbreeding program. (03 31 008)

h. Inbreeding effects on production and type traits. In cooperation with the University of Minnesota a project is in progress which is designed to develop and cross inbred lines of dairy cattle. A study was made in one line to determine the effects of inbreeding on production. The regressions of first lactation milk and fat on inbreeding of daughters were +64 lb. of milk and +2.3 lb. of fat. These effects are contrary to most reports of inbreeding. The data, however, consisted of only 35 pairs of first lactation records. The other inbred line was discontinued due to the poor performance of cows and to a constant decline in the strength of udders. This study demonstrates the hazards in developing inbred lines. It is extremely difficult to overcome inbreeding depression on both production and conformation traits. A new line has been chosen that would appear to have more potential for success than the previous line. (03 31 011)

i. Specific combining ability among inbred lines. At Ohio State a study is in progress to determine the importance of general and specific combining ability among inbred cattle lines. Crosses among four lines in four herds supplied data for an analysis of growth traits. Results showed significant maternal or herd effects for most of the traits studied at 5, 12 and 19 months of age. General combining ability was important at 5 months of age for wither height, at 21 months of age for chest depth, heart girth, chest width and hip width. Specific combining ability was significant only at 12 months of age for heart girth and hip width. This study suggests that it is not necessary to maintain and cross inbred lines in the improvement of dairy cattle for growth characteristics. (03 31 007)

j. Body growth and production performance of inbred lines and linecrosses. At Wisconsin data on a long term study of six inbred lines and crosses among them were analyzed. This study is summarized as follows:

1. Significant differences were found between outbreds and inbreds for all body measurements and first lactation production. These differences were in favor of the outbreds and the two-line crosses when compared to the inbreds, but the two-line crosses were superior to the outbreds. The differences between these mating systems were considered a measure of heterosis.

2. Inbreds out of inbred cows were more productive than inbreds out of outbred cows. This suggested that a greater amount of natural selection for fitness occurred in the inbreds.

3. The average production of cows in each mating system was below the AI controls.

4. The three-line and four-line crosses were equal in production to the two-line crosses. Continued crossing only maintained the level of performance obtained in the two-line crosses.

5. The estimates of the general combining abilities of the lines were not consistent from one mating system to another except for some of the traits among the linecrosses.

6. Differences among sires within lines were often as important as differences among lines. Sire differences were larger for inbred progeny than for linecross progeny.

This study indicates that inbreeding depresses growth and production traits. Crossing inbred lines overcomes the inbreeding depression but animals are still not as productive as those sired by randomly chosen bulls in AI service. (03 31 006)

k. The effect of thymectomy on growth of Brown Swiss calves. Brown Swiss calves in the crossbreeding herd at Beltsville have shown a high incidence of a "wasting disease" characterized by diarrhea, ruffled hair coat, hunched posture, poor growth and often death before three months. The symptoms observed were identical to those observed in laboratory animals suffering from natural or experimentally caused thymus deficiency. Twelve Holstein calves were thymectomized 24-48 hours after birth with no impairment of growth. Since the effect of thymectomy has been shown to be species and even strain specific in rats, 12 Brown Swiss calves were thymectomized. There was no impairment of growth and development. One sham-operated and one nonoperated animal did show all the symptoms of the "wasting disease" and upon necropsy were shown to have an abnormally small thymus. If thymus deficiency is the cause of the "wasting disease" in Brown Swiss, it would appear that it occurs prenatally. (03 31 055)

3. Genetic parameter estimates

a. Genetic parameters of feed efficiency. A statistical study was made using Beltsville Holstein data between the years of 1951-1961 to determine the heritability of feed efficiency and other production traits as well as the genetic correlations between efficiency and these traits. There were 661 lactations by 331 cows, which represented 17 sire groups and 225 daughter-dam pairs. The means for FCM yield, therms consumed, gross feed efficiency (therms of milk output/therms of feed input), weight and weight changes uncorrected for age and other environmental influences were: 11,610, 6,970, 1.66, 1,271 and +196; 13,940, 8,070, 1.73, 1,394 and +171; 15,480, 8,750, 1.77, 1,508 and +133; 16,210, 9,190, 1.76, 1,572 and +129; 16,360, 8,660, 1.89, 1,544 and +90 for the first, second, third, fourth and fifth parities, respectively.

The within cow phenotypic correlations unadjusted for age for all lactations between FCM yield and feed efficiency, FCM yield and therms consumed, therms consumed and feed efficiency, body weight and feed efficiency, body weight and FCM yield, were 0.64, 0.83, 0.11, 0.26 and 0.66, respectively. The correlation of weight change from beginning to end of lactation with all the variables was negative.

A within sire least squares analysis of variance was computed on 272 first lactation records to evaluate the effects of years, seasons, methods of milking (hand or machine), year x season, and weight change. Only the effects of season and weight change were significant sources of variation in feed efficiency. The effects of years and year by season interactions were not significant for efficiency but were for therms of energy consumed. Year variation in intake is probably associated with differences in quality of feed from year to year, especially the roughage components of the diet. In viewing the season constants, cows calving in January, February and March had the highest production, feed efficiency and energy consumption whereas those calving in April through June were the lowest.

The linear regression coefficients of weight change on FCM yield, feed efficiency and therms consumed during the first lactation were -1.86, -0.0017, and -0.35, respectively. These estimates were independent of sires, years, seasons, and year x season interactions. It is evident that weight change in the first lactation reflects growth in body tissue. In addition, the number of days open could influence weight change effects.

The estimates of heritability and genetic correlations were obtained by the daughter-dam regression technique; 225 first lactation daughter-dam pairs were analyzed on a within sire basis. The heritability of FCM yield, feed efficiency, therms consumed and body weight was 0.55, 0.22, 0.38 and 0.61, respectively. The genetic correlations between efficiency and FCM yield, FCM yield and therms consumed, therms consumed and efficiency and FCM yield and weight and efficiency and weight were 0.95, 0.94, 0.79, 0.30 and -0.12, respectively. These results indicate that selection for yield would bring about increased efficiency of feed utilization. (03 31 001)

b. Forage intake by sire groups. Preliminary analyses of data from Tennessee indicated that sire progeny groups differed significantly in their voluntary intake of hay and silage. Cows fed forage alone consumed about 0.8 lb./day more hay and 3 lb./day more silage than those also fed grain. Total dry matter consumption from forage was only 10% greater for the all-forage group. Forage consumption increased significantly as body weight increased.

Sire by ration interactions accounted for only about 3% to 4% of the variance in yield traits and were not statistically significant. (03 31 001)

c. Relationship of gross feed efficiency to other variables. In cooperation with the Utah State Experiment Station, a study of gross feed efficiency (therms of milk output/therms of feed input) for complete lactations of 358 cows was conducted. Gross efficiencies ranged between .146 and .349 with a mean of .260 and a standard deviation of .029.

The relationship between 17 variables and gross efficiency was studied. Gross efficiency increased approximately linearly with increases in age, number of days open, total dry matter consumption, grain consumption, percent grain in the ration, actual and mature equivalent production and initial body weight. An inverse linear relationship existed between gross efficiency and weight change during several parts of the lactation and for the total lactation period. When sires were ranked according to their USDA predicted difference, there was a positive relationship between sire ranking and gross efficiency. Ranking cows according to mean temperature during the first 90 days of the lactation resulted in a curvilinear relationship with gross efficiency with the lowest efficiency occurring at the highest temperature.

This study indicates, in general, that selection for high milk yield will also result in increased feed efficiency. Temperature and other environmental variables affect efficiency of feed utilization. (03 31 001)

d. Heritability and genetic relationships of milk flow characteristics. In cooperation with the University of Illinois milking rate characteristics were studied. Initial rate and maximum rate of milk ejection increased .16 and .10 kg./minute, respectively, for each 100 days increase in stage of lactation. Initial rate and maximum rate increased .186 and .173 kg./minute, respectively, for each increase of 1 kg. in field of milk per milking. The data indicate that maximum rate and initial rate are quite highly heritable and that time required to milk is greatly dependent on the yield of milk per milking. Selection for high production will foster indirect selection for high initial rate and maximum rate but longer times required for milking. Dairy men should not expect to milk high producers as quickly as low producers. (03 31 008)

e. Parity order effects on production and body measurements. At Illinois the first four lactations of 244 cows and body measurements of 275 cows were analyzed to estimate the effects of parity of birth on production and size. The effects of parity of birth on milk yield, fat percent, milk fat yield, body weight, wither height, body length and heart girth are not significantly different from zero. For general body size, second parity animals were consistently larger than the population mean, fourth parity animals smaller than the population mean and first and third parity animals near the population mean. This study indicates that dairymen should not breed their first lactation heifers to beef bulls or eliminate first parity heifers because they are deemed inferior for future production and growth characteristics. (03 31 008)

f. Relationships between fertility and body measurements. Body measurements and reproductive data were analyzed at Minnesota to estimate genetic and phenotypic correlations and heritabilities. Phenotypic correlations between prepartum body measurements and services per conception were small and nonsignificant. Most phenotypic correlations between body measurements and age at first service were negative, but not significant. Estimates of genetic correlations were extremely variable and lacked reliability. Heritability estimates for services per conception and age at first service were not significantly different from zero. This study indicates that the physical form of the animal is no indicator of her fertility characteristics. Dairymen cannot tell from visual examination if their cattle are fertile. The study also indicates that selection for reproduction characteristics would not be effective. (03 31 011)

g. Effects of pregnancy on body weight and paunch girth. At Illinois a study was made to determine pregnancy effects on body weight and paunch girth. Gross increases in paunch girth associated with pregnancy in cattle 24-48 months of age varied from .075 to .080 cm. per day after 150 days pregnant. Nonpregnant cows had true paunch growth measurements that varied from .020 to .030 cm. per day. The average net increase in paunch girth due to pregnancy after 150 days was from .047 to .057 cm. per day. Body weight of a cow increases with increasing days pregnant. At 150 days the fetus plus membranes and amniotic fluid weigh approximately 12.01 kg. At 230 days this weight increases to 35.6 kg. and at 300 days the total weight is 79.56 kg.

These data indicate that researchers should take into consideration changes in weight and body structure due to pregnancy when using either of these measurements to indicate the effects of experimental treatments. (03 31 008)

4. Genetics of erythrocyte antigens, biochemical polymorphisms and milk constituents

a. Genetics of erythrocyte antigens and other biochemical polymorphisms in cattle blood. The eleventh comparison test in cattle blood typing was held in January 1967. The program has grown to

include 34 laboratories in 23 countries. Blood for the test was taken from Austrian Fleckvieh and Austrian Braunvieh cattle. In addition to the conventional typing of red blood cell antigens, several laboratories, including the one at Beltsville, typed the samples for genetically controlled variation in blood proteins such as transferrin, hemoglobin, albumin, post-albumin, S α_1 -globulin, alkaline phosphatase and amylase. These types are determined by electrophoresis. An indication of the growth and scope of cattle blood typing is the number of reagents used for detecting specific blood antigens in the various laboratories. The number ranged from a low of 14 to a high of 75 with an average of 49. The older laboratories have the more complete reagent banks while the newer ones are building up their supply. The development and maintenance of blood typing reagents is a formidable task and comparison tests are helpful as a means of maintaining standardization and coordinating progress in this important field of genetic research. (03 31 003)

b. Blood type relationship to production. Three thousand cows were used in a study at Ohio to determine blood type relationships to production. The data were collected in eight herds and information on daughters of 100 sires is included. The analysis of these polymorphisms was conducted by eliminating the effects of herds, sires, years and seasons. The most significant effects were found with the transferrin locus. Animals with the E type seem to produce approximately 900 lb. less milk than cows without E. The A type seems most desirable. Cows homozygous for A produce approximately 800 more pounds of milk than those with the D type.

Significant differences occurred in the B antigen system only for percent Bf. Milk and fat production were not influenced by the genes in this system.

The S system showed significant effects for fat corrected milk and for pounds of butterfat. Animals with the H allele were the most productive. The fv system also seems to influence production with the V type being the most desirable.

These results suggest that polymorphisms in blood may be an aid to selection of desirable dairy animals. (03 31 056)

c. Association between blood type of sires and their production proof. In cooperation with Ohio State University, the blood antigen types and estimates of transmitting ability for production (USDA Predicted Difference) were compared for 1,582 Holstein bulls. This study included all blood typed bulls with 50 or more daughters with herdmates which were used in determining the USDA Predicted Difference (PD). These bulls had a total of 804,195 daughters with records, an average of 508 daughters per bull. Analyses between eight blood polymorphic systems (A, B, F, J, L, M, S, and Z) and the breeding value estimates were conducted. Two systems, B and L, appeared to be related to production. The relationship for the B system and the PD values was highly significant for kg. milk and

fat and percent fat. The association of the L system was significant for kg. milk and fat. Analyses adjusted for sire effects indicated that both the B and L systems are highly significantly related to the PD values for kg. milk.

This study indicates a possible value of blood typing in the initial selection of young bulls to go into artificial insemination studs. (03 31 056)

d. Blood serum transferrin type relationships to production and feed efficiency. In cooperation with Utah State University, a study was made of the relationship between serum transferrin type and 305-day ME fat-corrected-milk (FCM) production expressed as a weighted deviation from herd mates of 564 Holstein cows. A least squares analysis failed to show any significant differences among the nine herds involved or among genotypes. The gene frequencies were $Tf^A = .51$, $Tf^D = .49$. The means of the weighted FCM deviations were 295, -34 and 193 kg. for the AA, AD and DD genotypes, respectively. The herd x genotype interaction was also nonsignificant.

A study of the relationship between transferrin type and feed efficiency (Kcal milk produced: Kcal feed consumed) of 69 experimental cows indicated significant trends. Cows DD were superior to AD and AA cows. The mean FCM production was 3,243, 3,364, 3,871 and 5,061, 4,943, 5,410 kg. for AA, AD and DD cows on an all-hay and a standard ration, respectively. The differences in FCM production approached significance.

These studies indicate environmental factors may mask the effect of transferrin alleles in a normal herd situation, but when environmental variations are reduced sufficiently, the effects of the transferrins may be evident. (03 31 001)

e. Transferrin types help in parentage and identical twin determinations. A project in cooperation with Ohio State University was conducted on transferrin typed 520 animals in a parentage verification study. All 520 parentage combinations were in agreement with the genetic principle that the sire and dam of an offspring must have at least one factor in common with the offspring, and that an offspring could not have a transferrin factor not present in one of the parents. Blood from 32 supposedly identical twin pairs was examined for monozygosity verification. The analysis showed that two pairs had different cellular antigen types, one pair of which was also different at the transferrin locus. Ten pairs showed erythrocyte mosaicism which indicated dizygosity, and two of these pairs also showed a difference in transferrin type. Two pairs showed possible erythrocyte mosaicism of which one pair had unlike transferrin type. Sixteen pairs showed identical blood type and one of these had different transferrin type. Two pairs were found as possibly identical by blood type, but one of these pairs was not identical for transferrin type. Thus, transferrin type substantiated the blood type conclusion in 20 cases, it was no help in ten cases and it found two pairs to be nonidentical which had been classified identical by blood-type analysis. It was concluded that

transferrin types significantly increased the effectiveness of determining animal relationships. It appears to be most useful in cases of multiple birth and among groups of cattle with similar cellular antigen types. (03 31 056)

C. Poultry

1. Genotype-environment interactions in meat and egg stocks of chickens. Studies with broilers indicate that stock by environment (growing location, trial, floor space density, parent flock location) interactions are of minor practical importance. Interaction variance components of this type generally made up less than 2% of the total phenotypic variance in body weight regardless of age of measurement. This was true in three separate broiler studies involving two or three trials per study. Although genotype by environment interactions were statistically significant in the first of the three studies (not in the latter two studies), the interaction components contribution to the total variance was of small magnitude. For traits other than body weight viz., feathering and mortality, interactions also appear to be of minor concern when put in terms of their contribution to the total variance rather than in terms of probability statements.

Results from studies with egg production stocks are not as clear-cut as those from broiler studies. In the one series of trials published to date, interactions appeared to be important for several traits. (03 29 003)

2. Cage density study. (Genotype-environment interactions) Six commercial egg production stocks are currently being tested in three cage densities (one, two and five birds per cage unit). Each stock by cage density subclass is replicated twice with 50 pullets being housed at 20 weeks of age in each of 36 subclasses. The current trial is the first of two trials to determine whether stocks tend to respond the same under various levels of crowding or whether certain stocks are more adapted to certain cage densities. (03 29 010)

3. Cytogenetic studies. In order to learn the techniques for working with avian mitotic chromosomes, the sandhill and whooping cranes were studied. Examination of feather pulp cells showed varying chromosome numbers. The macrochromosome number was constant while the microchromosome number varied. Variation was by as much as 20 to 30 chromosomes. Reasons for this variation appear to be due to interpretation of satellited chromosomes, connections between chromosomes and uncertainties about centromeres. Several chromosomes were attached to one or more nucleoli. These nucleolar structures were visible into anaphase. In noncolchicine treated cells some microchromosomes were very thin and attenuated. The chromosome number in the cranes appears to be lower than reported for other birds. .

Several hybrids have been made in preparation for study of the meiotic chromosomes. These are Chicken-Ringneck Pheasant hybrids, Reeves-Ringneck Pheasant hybrids and Chicken-Japanese Quail hybrids.

The chicken-quail hybrids have been reported to be sterile. Therefore, injections of PMS have been made in order to further the progress of spermatogenesis. Several hybrids had increased testis size. This increase was correlated with the appearance of the foam gland characteristic of the Japanese quail. (03 29 011)

4. Selection plateaus in Japanese quail. Two lines of quail were developed to compare selection progress under differing nutritional environments. Selection was based on four week body weight when quail were fed either an adequate protein diet (P) or a protein deficient, thiouracil containing diet (T).

After five generations, the P and T lines were 23 and 18 grams above their respective controls. These values constitute a 22% increase above the control in body weight for the P line and a 21% increase for the T line. The average selection differentials for the T line (10.4) were larger than those for the P line (8.5). Realized heritabilities, estimated by plotting the generation means against the cumulated selection differentials (for four week body weight) were $.48 \pm .15$ and $.39 \pm .08$ for the P and T lines, respectively. (03 29 013)

5. Rancombred control populations. Four rancombred control populations were maintained for use by cooperators as gene pools and as genetic and environmental controls. Two populations are maintained at Lafayette, Indiana, primarily for egg production research and two at Athens, Georgia, for meat production research. Hatching eggs from these stocks are supplied to cooperating universities, to random sample tests, to universities outside the region, and to commercial poultry breeders. (03 29 002,003)

6. Evaluation of breeding systems. The evaluation of breeding systems and selection methods was continued at the North Central Regional Poultry Breeding Laboratory and five cooperating stations. Common foundation stocks are being utilized by all locations and the trait under selection is percent hen-day egg production to approximately 300 days of age. Data are simultaneously collected on other traits of interest in order to study the correlated response of these traits to selection for egg production. Selection pressure is maintained at approximately 25%.

The Indiana station completed the fifth generation of closed flock index selection and reciprocal recurrent selection involving the Purdue Pool and Cornell Control populations. Crosses of the two index selected lines and of the index selection within a cross of the two control populations were also tested. Gains in rate of production to January 1 were not as great as in the first four generations for the index selected lines. The crosses of the two selected lines show positive gains in rate of production. One

of the crosses between the reciprocal recurrent selection lines showed a large gain in this generation, while the reciprocal of this cross showed no gain. No gain was realized in either of these crosses in previous generations. Neither of the reciprocal recurrent selection lines showed a gain in rate of production, nor did the selected cross of the two controls.

The design of the Kansas project is the same as the Indiana project except that the Regional Red Control has been used instead of the Purdue Pool Control. Results from Kansas indicate that progress is being made in improving rate of production in all of the lines and crosses except in the Reciprocal Recurrent Selection lines. The greatest increases are being made in the index selected pure lines.

The Missouri station completed seven generations of selection in the following systems: intraflock with selection based on an overall performance index; crosses produced from the mating of inbred male lines with segregating female lines which are selected on the production records of their crossbred half sisters; family population selected and reproduced by pure separate line methods. The criterion of selection has been rate of production from first egg to 34 weeks of age. The intraflock, family selection and cross means show superiority of 3, 8 and 5% over the controls for production from first egg to 34 weeks; 8, -1 and 7% for 34 to 64 week rate of production and 10, 6 and 7% for production rate from 22 to 64 weeks of age. The means for age at first egg are below the controls in all systems. Mature egg weight is below the controls in all systems except the intraflock, while body weight appears to be increasing in all three selection systems.

Results at the South Dakota station indicated that crosses between Barred Plymouth Rock sires and White Leghorn females showed a depression in egg numbers while mortality was higher than in the purebreds. Crossed involving inbred dams laid more eggs than did the cross involving noninbred dams. The inbred linecrosses showed a higher incidence of broodiness. In reciprocal crosses of Rhode Island Reds with inbred White Leghorn females a 29 egg difference in production was observed. Egg size for all crosses was higher than for purebreds.

The fifth generation of inbreeding with and without selection in Rhode Island Red and White Leghorn lines was continued at the Wisconsin station. The nonselected inbreds were approximately 20% below the randombred controls and noninbred selected populations in rate of production. The selected inbred populations were approximately 20% below the control in rate of production. The inbreds, as in previous generations, show increased mortality, delayed sexual maturity and an increased percentage of floor eggs.

Samples of 50 populations were compared under uniform environmental conditions at the Regional Laboratory. Except for four populations all were tested in three replicates of 30 females each. Appropriate control populations were also included and 16 traits of economic interest were

measured on all populations as deviations from control. The three control populations, Cornell, Red and Pool again reflect stability for all traits measured. The index selection systems under study have responded more favorably to selection for egg production to January 1 than have the reciprocal recurrent systems. Dam family and sire family selection appear to be making more consistent progress than individual selection. Selection for phenotypic extremes of body weight and egg size appears to result in decreased egg production. The results of this year's evaluation support the finding of previous years, that increased egg production is associated, in most cases, with decreased egg size, poorer albumen quality, thinner shells and decreased sexual maturity. Individual and family selection appear, as in previous years, to be superior to reciprocal recurrent or recurrent selection for the improvement of egg production. Data from several generations of selection in these systems are now being analyzed and will permit a comparison of specific systems of selection. (03 29 002)

D. Sheep and Fur Animals

1. Selection for weight and rate of gain in ewe lambs. To obtain information on the most effective period during a lamb's growth in which to select for increased weight and rate of gain, 3,327 unselected ewe lambs were weighed at birth in April, at weaning in August and then at monthly intervals until shearing in the following May at Dubois, Idaho. Separate determinations were made on inbred, noninbred, and crossbred groups involving Rambouillet, Targhee, and Columbia breeds.

Heritabilities for weight tended to be highest during March, April and May when animals were in the feedlot, ranging from 0.3 to 0.6. Heritabilities for gains generally were highest for feedlot gains (January through April at 0.09 kg./day) and ranged from 0.4 to 0.7. Heritabilities of gains during September through May (0.03 kg./day) were almost as high, but those of gains on dry fall range from October through December (0.00 kg./day) were lowest, usually under 0.4.

After considering genetic correlations, the most effective period on which to base selection for improving preweaning gain generally is the preweaning period; however, in some instances selection on weaning and postweaning weights will be slightly more effective than that on preweaning gain itself. Under the management plan used in this investigation, the most effective period for selecting for postweaning gain is generally the feedlot period. Except in the noninbred Targhees and the inbred Columbias, selection for feedlot gain usually will result in slight genetic improvement in preweaning gain. (03 33 003,004)

2. Genetic and environmental interactions. Interactions were examined on ten traits of 550 weanling crossbred lambs of predominantly Columbia times Rambouillet breeding and 560 crossbred lambs sired by Rambouillet, Targhee, Columbia and Suffolk rams at Dubois, Idaho. A random half of the lambs were weaned at an average age of 85 days and placed on irrigated

brome-timothy-clover pasture supplemented with an alfalfa pellet containing 37% barley. The remaining half were left with their dams and taken to lush, mountain summer range. Final observations on all lambs were made at the time of weaning the mountain grazed group at an average age of 128 days.

In the group of lambs sired by four breeds of rams, differences among the breed crosses were highly significant for all traits except average daily gain. Differences among the feed treatment groups were significant only for fatness and fleece grade.

Notwithstanding the significant differences among the types of crosses, the interactions between type of cross and feeding group in both kinds of lambs seem generally of little importance under the above management system. Hence, the effect of differing nutritive environments of the above nature on weight gains, face cover, neck folds, staple length and fleece grade would be similar for each kind of cross. The effects on fatness (and possibly mutton type) may be slightly different for different crosses. Crosses from Columbia type dams seem to get slightly fatter in the feedlot, whereas crosses from Targhee type dams seem to get somewhat fatter on lush mountain range. (03 33 003,004)

3. Effect of breed of sire upon weanling lamb production of linecross and topcross ewes. Rambouillet, Targhee, Columbia, and Suffolk non-inbred sires were crossed upon three groups of ewes at Dubois, Idaho. Group 1 contained one-half linecross Rambouillet ewes plus Rambouillet sired ewes from Rambouillet, Targhee, and Columbia dams. Group 2 contained linecross Targhee ewes plus Targhee sired ewes from the three breeds of dams. Group 3 contained linecross Columbia ewes plus Columbia sired ewes from the three breeds of dams.

Regardless of which group of ewes were considered, weanling lambs from Suffolk sires were clearly superior in weight, mutton type, fatness, rate of gain and overall merit to lambs from any other breed of sire. Ewes bred to Suffolk sires also excelled in pounds of lamb weaned per ewe bred by 8 to 20 pounds. Lamb production tended to be poorest when the breed of sire was the same as the breed of sire of his mates. (03 33 003,007)

4. Lamb production of Rambouillet, Targhee, and Columbia inbred, linecross, and crossbred (topcross) ewes outcrossed to Rambouillet, Targhee, Columbia and Suffolk rams. Ewes developed by topcrossing Rambouillet, Targhee or Columbia sires each upon dams of Rambouillet type, Targhee type, and Columbia type were contrasted with purebred linecross (non-inbred) and inbred ewes in percent of lambs weaned and pounds of lamb weaned per ewe bred at Dubois, Idaho. Groups of these topcross, linecross, and inbred ewes were each mated to the same sire with four breeds of rams being involved.

Regardless of the breed of ram to which mated, the ewes of topcross origin clearly excelled the linecross and particularly the inbred ewes in percent of lambs weaned (from 5 to 75%) and in pounds of lambs weaned (from 5 to 50

pounds) per ewe bred. In most pens containing Targhee or Columbia linecross and inbred ewes, linecross ewes excelled the inbred ewes in production. However, in pens containing Rambouillet linecross and inbred ewes, inbred excelled linecross ewes except when mated to Targhee rams. (03 33 003,007)

5. Breed comparisons and crossbreeding. Hampshire, Columbia-Southdale, Targhee, Suffolk and Dorset breeds are being compared at Beltsville, Maryland, with respect to their production of lamb and wool as purebreds and their relative merit in a crossbreeding program. This comparison is based on an index that considers both pounds of lamb weaned and pounds of wool sheared. In 1967 this index ranked the Targhee ewes first (105.4), Suffolk second (101.8), Columbia-Southdale third (86.1), Hampshire fourth (80.1) and Dorset fifth (74.7). These breeds were ranked in this same order in 1966. All possible crosses and reciprocal crosses among these breeds were made. Targhee ewes mated to rams of the other breeds had the highest average index (141.7). The highest individual breed cross index resulted from crosses involving Dorset rams on Targhee ewes (156.5) and Suffolk rams mated to Targhee ewes (152.0). For all crossbred matings the index values ranged from 156.5 to 40.6 and for the purebred matings from 105.4 to 74.7. The Dorset ewes performed better in purebred matings than in crossbred matings. (03 33 001,021)

6. New strain of sheep for lamb and wool production. In 1961 work was started at Beltsville, Maryland, to determine the effectiveness of selection in developing a strain of sheep which will reproduce at any time of the year and more often than once each year. Originally the ewes were bred to lamb every eight months - September, May and January. However, at present the open ewes are kept with the rams at all times. Through 1966 a total of 1,002 matings have been made resulting in 362 ewes lambing, 491 lambs born and 344 lambs weaned. Sires born in the flock and used in breeding had dams which averaged 209% of lambs per ewe year compared to 70.5% for all ewes lambing in this flock. These dams weaned an average of 107 pounds of lamb per ewe year. The lambs average about 70 days of age at weaning. The best reproductive performance for the flock as a whole results from fall matings, and the poorest from spring mating with the winter mating intermediate. (03 33 022)

7. Effect of breed on lambing twice yearly. Performance of Dorset, Rambouillet and Dorset-Rambouillet ewes in a twice-yearly lambing program has been studied at El Reno, Oklahoma, during the past two seasons. A higher percentage of the crossbreds have lambed in the fall; about an equal number of crossbred and Rambouillet ewes have lambed in the spring. The percent of ewes that lambed, rebred and conceived has been highest for the Rambouillets during the fall and similar for the three groups in the spring. Rambouillet ewes have had a shorter average interval from lambing to conception followed by the Dorsets. The crossbreds have been superior in the number of lambs produced per ewe lambing. A higher percentage of all ewes have lambed in the spring, gave birth to more lambs and have reared a greater percent of the total lambs born. The survival rate of the spring-born lambs has been

about 15% higher than for the fall-born lambs. Low birth weight is probably a contributing factor in the higher mortality rate of the fall-born lambs. (03 33 017)

8. Improvement of commercial range sheep. To investigate the rate of improvement in wool and lamb production that could be made under practical ranch conditions with a range flock of sheep, a selection program was initiated in 1957 with the Redd Ranches at La Sal, Utah. This project is also in cooperation with the Utah Experiment Station. About 1,200 ewes were chosen from 15,000 on the basis of phenotypic merit. These ewes are mated to rams raised on the ranch from these select ewes and are chosen on the basis of fleece weight, body weight, staple length, absence of wool on the face and freedom from defects. All ram lambs born in the flock are individually weighed, measured, and scored and about half retained for possible breeding replacements. Since the beginning of the program, staple length and face covering have responded the most to selection. Improvement in body weight and fleece weight at yearling age has been obscured by large yearly sources of variation. A control group of ewes lambing with the select ewes and made up from ewes mated to second best rams was initiated in 1965. This control group produced lambs that could be compared with the lambs produced by first choice rams. At 100 days of age the select group lambs were 10 pounds heavier and had .12 inch longer staple. No difference was evident in face covering in the two groups. (03 33 008)

9. Genetics of mink with emphasis on mutant traits. The study of combinations of mutant genes affecting coat color is continuing in a herd of approximately 300 female mink in cooperation with the University of Wisconsin. The mutant gene J, which causes a notable darkening of the pigment when introduced individuals of the "wild type" or standard dark color was found not to be epistatic to a number of other well known mutant genes affecting color in this species. (03 34 001)

10. Immunogenetics of the mink. The immunogenetics of the mink is under intensive study in cooperation with the University of Wisconsin. Four blood type systems (A, D, E and G) discovered by the use of agglutination techniques have already been reported. Another subtype has been detected in the A system (A2) which brings a total of five specificities (A, A2, B, B2, C) for this single system. Three new blood types have been found which are as yet unnamed. Three allotypes have been detected but the genetics involved are not yet completely determined. It has been possible to determine the particular serum proteins to which the antibodies of a given reagent react by the combined use of electrophoresis and precipitation tests. (03 34 001)

E. Swine

1. Develop new and improved selection aids and techniques

a. Transferrin and prealbumin polymorphisms in swine selected for backfat thickness. A polyacrylamide gel electrophoresis system was used to phenotype serum transferrin (Tf) and prealbumins (Pa) in

84 sows, 44 boars, and 538 progeny of Duroc and Yorkshire swine selected for backfat thickness for 11 and 9 generations, respectively. The samples were collected from Yorkshires and Durocs that were represented by equal numbers from the high-fat, low-fat, and control lines for both breeds. The parents and progeny of the selected lines were probed for backfat thickness at 77.3-81.8 kg. The average backfat thickness of the Duroc and Yorkshire high, low and control lines was 5.49 cms., 2.69 cms., 3.78 cms., and 3.96 cms., 2.31 cms., 3.02 cms., respectively. Duroc gene frequencies were Tf^A , 0.000; Tf^B , 0.996; Tf^C , 0.004; Pa^A , 0.49; Pa^B , 0.51. Yorkshire gene frequencies were Tf^A , 0.45; Tf^B , 0.55; Tf^C , 0.00; Pa^A , 0.98; Pa^B , 0.02. The observed phenotypic distributions did not deviate significantly from those expected by the Hardy-Weinberg equilibrium formula and segregation analysis. Contingency table data indicate the loci of the two polymorphisms are segregating independently. There was no significant difference in backfat thickness between prealbumin or transferrin phenotypes by a least squares analysis of variance in the Yorkshires and Durocs. The least squares analyses and Hardy-Weinberg distributions did not show an association between backfat thickness and serum transferrins or prealbumins. Studies of this type are important in our attempt to develop correlations between genetic polymorphisms and economic traits of swine. (03 32 007)

b. Identification of genetic polymorphisms in sows' milk. Two distinct types of protein polymorphisms in the whey and the casein fractions of sows' milk have been identified. Milk samples were collected over a two-year period from 125 Duroc, Yorkshire and crossbred sows in the breeding and nutrition herds at Beltsville and the milk from these sows was analyzed for protein types. Both polymorphisms appear to be controlled by two codominant alleles. The casein polymorphism migrates in the same region as bovine β -casein and consists of two bands, designated Cn_3^A and Cn_3^B . The whey protein polymorphism migrates in the same region as bovine- β -lactoglobulin and consists of two bands, designated as Wh_1^A and Wh_1^B . A different buffer system must be used to properly separate the whey and casein protein fractions. In both cases, the subscript indicates one of many regions on the gel. The homozygotes possess one band and heterozygotes possess both bands of equal intensity. The gene frequencies of the casein fraction for the Durocs were Cn_3^A , 0.28 and Cn_3^B , 0.72. The Yorkshire gene frequencies were Cn_3^A , 0.22 and Cn_3^B , 0.78. Crossbred gene frequencies of the caseins were Cn_3^A , 0.27 and Cn_3^B , 0.73. The gene frequencies for the whey protein in the Duroc were Wh_1^A , 0.95 and Wh_1^B , 0.05. Yorkshire gene frequencies for the whey proteins were Wh_1^A , 0.25 and Wh_1^B , 0.75. Crossbred gene frequencies for the whey protein were Wh_1^A , 0.71 and Wh_1^B , 0.29. Phenotypic distributions calculated from the Hardy-Weinberg equilibrium formula and a segregation analysis indicate that the polymorphisms are controlled by two codominant alleles. Further family studies are needed to substantiate the evidence presented for these proposed genetic polymorphisms. (03 32 007)

c. Isolation of a crystalline polymorphic protein in sows' whey. A polymorphic protein has been isolated in crystalline form from the milk of individual sows shown to be homozygous for one of the two polymorphic proteins

so far discovered. The two proteins show no differences in electrophoretic mobility in polyacrylamide gels containing urea or mercaptoethanol or in gels of pH lower than 6.0. Analysis of the two fractions show that they differ only in the amount of the amino acids alanine and valine. Genetic clues stemming from analysis of sows' milk may someday enable swine breeders to select sows that produce more and/or better milk for feeding their young. Furthermore, protein types can be used as genetic markers to help breeders find the best boar-sow mating to produce the desirable offspring. (03 32 007)

d. PL 480 Project - Investigations on blood groups in the new racial group of the Zlotnicka pig (Poland). Forty-one reagents for blood typing were prepared. One hundred-twenty progeny groups of swine were blood typed and the genetic analysis of the results is underway. Two hundred seventy-three bacon pigs of the Polish Large White breed were blood typed and studies were made of the performance of the different groups. Individuals that were O and Gb positive and Ka and Po₂ negative reached 96 kg. live weight in a significantly shorter time than others. Gilts that were Ea and Kb positive appeared to have leaner hams. Additional data are being collected to extend these studies. (03 32 027)

e. Selection for combining ability. At the Oklahoma station, selection for combining ability has been carried through four cycles with litters produced by crossbred gilts. Purebred replacements for initiating the fifth cycle were selected on the basis of the productivity of their crossbred half-sibs. Selection differentials for replacement animals were positive for number of pigs born, number of pigs raised to 21 days, and 21 day litter weight for each of the four cycles. Replacements also showed positive selection differentials for weaning weight of litters in which they were raised. In the first two cycles, crossbred dams weaned lighter litters than control line dams; while in the last two cycles, crossbred dams weaned larger litters of heavier pigs. Control line dams were consistently more productive than purebred dams during the first four cycles, but no decline in performance of purebreds has been noticed. (03 32 021)

At the Minnesota station, selection based entirely on performance of purebred progeny gave similar results to those from selection based partly on purebred and partly on crossbred performance in the production of a specific three-breed cross. These results suggest that improved crossbred performance will be obtained by merely selecting the best purebreds. (03 32 005)

f. Selection for growth in mice. Selection for postweaning growth in mice at Minnesota continued to be effective after 35 generations. Analysis of data from the first 29 generations of selection gave a high positive (0.89) genetic correlation between growth rate and litter size. Litter size increased by 2.87 mice which is 64% of the predicted response. (03 32 005)

g. Selection differs between seasons. At Missouri, samples of two Poland China lines, one of which was selected for low backfat for five generations in the spring and the other in the fall, were tested in both seasons. In sow productivity, the fall line was superior to the spring line in both seasons. Data on individual pig traits are incomplete, but postweaning daily gain and backfat thickness averaged higher for the fall line in the fall season. (03 32 011)

h. Miniature pigs. The miniature swine breeding project at Beltsville is now in its fourth year with the primary purpose being the development of a small white pig from crosses of the Hormel and Hanford strains of miniatures. All but two of the 42 litters farrowed carried genes of the two strains and 26% of the pigs were classified as white at birth with the remainder being colored. Litter size averaged 7.2 pigs farrowed and 6.4 pigs weaned per litter with an average pig weight of 681 gms. at birth and 8.1 kg. at 56 days of age. A sample of 194 pigs self-fed in drylot averaged 31.4 kg. at 140 days of age. Daily gain averaged 132 gms. from birth to weaning and 277 gms. from weaning to 140 days of age.

i. Reciprocal recurrent selection. The reciprocal recurrent selection project being conducted at Beltsville, Maryland, is now in the second phase of the sixth selection cycle. In accordance with the pattern set in 1957 for odd-numbered years, this year's litters are the product of intrastrain matings using animals selected on the basis of their cross progeny performance in 1966. The inbreeding of the two strains used in the crossing now averages 29% for the LL strain and 13% for the BB strain. Litter size at birth averaged about 11.7 and 11.0 pigs for the LL and BB strains, respectively. These figures are higher by about 1.2 and 0.4 pigs than those for the two control strains derived from the same sources as the LL and BB strains. Litter size and litter weight at weaning, on the other hand, showed little or no advantage for either the LL or the BB strain. Backcross litters out of LB and BL gilts and by LL and BB boars exceeded straight LL and BB control strain litters by 2.2 and 2.4 pigs or by 29 and 30% in litter size at birth; by 1.8 and 2.0 pigs or by 27 and 28% in litter size at weaning; and by 108 and 122 pounds or by 37 and 40% in litter weight at weaning. These advantages in favor of single cross dams are slightly higher than those shown by fifth cycle gilts in 1965. (03 32 003)

Detailed analyses of the Miles City data from reciprocal crosses between the Montana "Select" and Yorkshire "Select" strains were completed for the litter traits. Linear regressions of least squares means on years showed little or no improvement in litter size for crossbred litters out of Montana No. 1 gilts, whereas for crossbred litters out of Yorkshire gilts litter size increased by about 0.14 pig per year at birth and by about 0.12 pig at both 21 and 56 days. Litter weight at the same three ages increased by about 0.0, 0.4 and 2.0 pounds for crossbred litters out of Montana No. 1 gilts and by about 0.1, 0.5, and 3.6 pounds for crossbred litters out of Yorkshire gilts. While the results obtained generally point in the

direction in which selection was practiced, the small improvement shown by both litter size and litter weight suggests rather strongly that overdominance was relatively unimportant as a source of variation in these traits. (03 32 001)

2. Develop improved breeding plans for swine

a. Pig learning ability. In a study of learning ability, 422 pigs consisting of Poland Chinas, Yorkshires, and Poland x Yorkshire crosses were tested in a T-maze on three consecutive days with five trials per day beginning at 18 days of age. The exit point from the mazes was randomly allocated for every trial with a visual clue located so as to indicate the direction of a correct response. Correct responses for the five trials each day averaged 55.2%. A least squares analysis of variance showed highly significant differences ($P < .01$) both between sexes and among mating systems. Females exceeded males by 3.5 in percent correct responses. The results for mating systems showed Poland x Yorkshire pigs at the top, followed by Yorkshire, Yorkshire x Poland, and Poland, in that order. The results show that differences among mating systems were due more largely to breed differences in maternal influences than to heterosis effects. (03 32 024)

b. Heredity and environment. Weaning records for about 30 herds completing all requirements of the Official Duroc Production Tested Herd Program in two years were studied to evaluate the relative influence of heredity and environment on sow productivity. Herd differences were considerably more important than age of dam for all traits and were greatest at weaning. Age of dam had the greatest effect on traits measured at birth but also had an important effect on weaning weight. Season had little effect on any trait in either year. Intraherd repeatabilities of litter size at birth and at weaning and of litter weight at weaning were 0.25, 0.16, and 0.07, respectively. (RSBL)

Data collected on 3,781 litters born at the Indiana, Oklahoma, and Wisconsin stations during the years 1944 to 1958 were used to evaluate the effects of heredity and environment on number of pigs born alive, number living through the first day, number alive at weaning (56 days), litter weight at weaning, and number alive at 154 days of age. A least squares analysis showed that the effects of station, breed, farrowing history, year, season, inbreeding of dam and litter, and age of dam, were generally significant for all traits. Estimates of heritability derived from the regression of daughter on dam were $0.09 \pm .04$, $0.08 \pm .04$, $0.13 \pm .05$, $0.19 \pm .05$, and $0.10 \pm .04$, respectively, for the five traits. Corresponding estimates of repeatability were $0.17 \pm .03$, $0.13 \pm .03$, $0.06 \pm .03$, $0.05 \pm .03$, and $0.07 \pm .03$. The regression of daughter means on record of dams deviated significantly from linearity for litter size at birth, the slope being negative up to a litter size of six. (03 32 022,024,006,RSBL)

c. Heritabilities and genetic correlations. A study of data from the Oklahoma station for 228 pigs, representing 76 boar-barrow-gilt litter-mate trios, showed that growth rate, backfat thickness, and loin-eye area were significantly correlated with yield of lean cuts in both barrows and gilts. Loin-eye area gave correlations of 0.53 with percent lean of live weight and 0.39 with percent lean of carcass weight. The correlation of backfat measurements taken at 175 pounds with measurements at 200 pounds was lower for boars than for either gilts or barrows, and there was less variation in backfat thickness among boars at 175 pounds than at 200 pounds. (03 32 022)

Studies of boar semen characteristics disclosed high heritabilities for sperm number and lactic acid concentration, but standard errors of both estimates were rather large. (03 32 006)

The Minnesota No. 4 breed, synthesized from the Minnesota No. 1, No. 2, and No. 3 breeds, was found to perform equally as well as the specific three breed cross involving the same breeds. The latter exceeded the rotation cross only for loin-eye area. (03 32 005)

d. Heterosis. A study at the Oklahoma station of 12 years' data on 1,700 litters with 7,520 pigs representing Duroc, Beltsville No. 1, and Hampshire lines of breeding and four specific crosses among these lines was completed during the year. Estimates of heterosis effects were obtained on a within-line basis using least squares procedures. Purebred dams with crossbred litters farrowed smaller litters (-10%) than purebred dams with purebred litters but showed advantages for pig weight at birth (3%), pigs weaned per litter (3%), survival rate (19%), pig weight at 56 days (12%), and litter weight at 56 days (6%). Crossbred pigs excelled purebred pigs in daily gain (6%), carcass length (1%), and loin-eye area (4%). Crossbred sows with three-line cross pigs excelled purebred sows with similar three-line cross pigs in number of live pigs per litter (11%), litter weight at birth (14%), pigs weaned per litter (5%), and litter weight at 56 days (14%). Three-line cross pigs excelled purebred pigs of the same three breeds in length of carcass (1%) but required more feed per unit of gain (2%), had lower daily gains (-5%), and had smaller loin-eye areas (-7%). (03 32 022)

In North Carolina, data collected on 235 litters born over a four year period and representing certain combinations of the Duroc, Hampshire, Landrace, Poland, and Yorkshire breeds were used to evaluate the effects of crossbreeding on sow productivity and pig performance. For litter traits, Duroc females were superior to Hampshire females, while pigs from Hampshire sows were heavier and had less backfat at 140 days. Landrace sired pigs were superior to Yorkshire sired pigs in both 140-day weight and backfat thickness. In three-breed crosses, one-half Hampshire sows excelled one-half Duroc sows in litter traits. There was little difference between Landrace and Yorkshire in three-breed crosses. Of the three-breed-cross dams compared, those of one-half Duroc breeding were superior for litter traits. In four-breed crosses, pigs with Yorkshire breeding grew slightly faster than those having Landrace breeding. (North Carolina)

e. Predicting percent lean cuts. The following formula, which has been derived for predicting percent lean cuts for barrows and gilts at live weights of 180 to 220 pounds, is being used in the field program of the Ohio Pork Improvement Association: Estimated percent lean cuts = $65.4 + 0.03$ live weight, -2.2 backfat thickness, and -6.4 ham fat. (Ohio)

f. Early weaning. A second set of trials designed to determine the effects of early weaning on subsequent growth and fat deposition was completed at Beltsville with Duroc and Yorkshire pigs of fall 1966 farrow. As in 1965, the plan was to wean one or two pigs of a particular sex from each of several litters at 35 days of age and feed out these pigs with their littermates weaned at 56 days of age. Based on comparisons involving 136 early weaned and 176 late weaned pigs, 56-day weight in Durocs averaged 6.8 pounds less for early than for late weaned pigs, while in Yorkshires, the mean difference was 8.0 pounds. In contrast, daily gain from 56 days of age to a mean probing weight of about 175 pounds did not differ materially between early and late weaned pigs. Also, backfat thickness differed only slightly between the two groups. These results agree rather closely with those reported last year. They suggest that weaning pigs at five weeks of age has little or no effect on their subsequent growth or on backfat thickness. (03 32 002)

F. Broadly Based

1. Genetic control of growth. A study of the genetic control of growth in mice as affected by protein metabolic activity was completed. Protein metabolic activity was measured as the rate of transport of a nonmetabolizable amino acid into muscle tissue. Protein metabolic activity showed a positive genetic correlation with body weight, carcass weight and nitrogen content of carcass at 28 days of age, but a negative genetic correlation at 42 days. The heritabilities of body weight, carcass weight and carcass nitrogen content were high, but that for rate of amino acid transport was low. The genetic correlations indicate that protein metabolic activity is associated with weight gain at a given age in such a manner that it might be used as a measure of growth. (03 98 010)

2. Basic research on blood antigens and antibodies

a. Embryological studies on the development of the A_2^{c1} antigen in pigeons. Studies initiated to detect the first appearance of the A antigen have been continued. Embryonic bone marrow has been cultured for short periods and the presence of A_2^{c1} activity has been detected in the cultured cells.

b. The nature of antigenic specificity. Studies have been initiated on the development of the "Hi" substance on chicken red cells. It has been found possible to culture plugs of bone marrow for as long as three days. Most of the studies have been conducted with bone marrow plugs for periods of two to four hours. Maximum survival of cells in the

plug were achieved with levels of plasma up to 75% with the plasma of a bone marrow donor or his dam. The use of pancreatin-plasma mixtures made it possible to break up the plugs without destroying the cells and permit cell counting. The use of conventional fluids such as enriched Eagle's Basal Medium resulted in poor survival and low agglutinability. Maximum agglutinability with Pisum arvense was achieved in the presence of 75% plasma. The control in the experiment was Phaseolus lunatus.

These procedures will find additional use in the studies of tritium labeled marrow cells assayed with liquid scintillation methods.

c. Antibody structure--characterization of P. lunatus lectin. A procedure has been developed for achieving a 100 fold purification with 20-25% recovery of the active anti-A lectin from extracts of Phaseolus lunatus. The method utilizes fractionation with ammonium sulfate in conjunction with isoelectric precipitation, followed by molecular filtration through agarose (Biogel A1.5).

Reaction of the lectin with reagents such as mercuric chloride, iodoacetamide, N-ethylmaleimide 5,5'-dithiobis-2-Nitrobenzoic acid (Ellman's reagent), all of which are known to react with sulfhydryl groups, blocks the hemagglutinating activity. The activity can be completely or partially restored in the case of mercuric chloride and Ellman's reagent, respectively, by reaction with sulfhydryl compounds. These results indicate that one or more free cysteine sulfhydryl groups are essential for activity, and are, therefore, probably located in the "active center" of the lectin molecule.

d. Synthesis of antibodies--protein changes in the developing seed of the lima bean, Phaseolus lunatus var. Thaxter. Studies were initiated on the development of the anti-A lectins in Phaseolus lunatus at the Blood Antigen Pioneering Research Laboratory. These studies were completed at the University of Houston. Starch gel electrophoresis of lima bean seed constituents were conducted as the embryo grew and differentiated. During this period some seed components continued to be detected, and other components appeared as development progressed. The concentration of a third group of seed constituents decreased so that they could no longer be detected by electrophoresis. Zymograms of α -1, 4-glucan: ortho-phosphate glucosyl transferase established that this constituent remained relatively unchanged.

The titers of anti-A activity prior to the 13th day of development are essentially zero. Between the 13th and 15th days the titer increased abruptly to a weak positive reading, with undiluted lectin on the 14th day, to strong reactions (1:16) on the 15th day and continues to increase to maximum values on the 20th day of development. The lectin was shown to migrate toward the anode when subjected to starch gel electrophoresis.

- e. The effects of x-rays on viability genes with special reference to their action in heterozygotes and the mechanism of heterosis.

Artificial populations of Drosophila melanogaster were established in small plastic containers. Each population was started with equal numbers of flies heterozygous for a Curly-chromosome and a given irradiated chromosome and flies heterozygous for the same Curly-chromosome and an unirradiated chromosome. Since the homozygotes were either lethal or sterile, only fitness of the heterozygotes for the unirradiated chromosome determined the fate of the populations. The viability coefficients of the homozygotes and heterozygotes of the irradiated and unirradiated chromosomes were determined prior to the establishment of the populations. In one experiment populations were started with chromosomes which had been exposed in spermatozoa to 2000 r. In a second experiment, populations were started with chromosomes which had been exposed in spermatogonia to four doses of 3000 r each. A third control experiment included only nonirradiated chromosomes. In both radiation experiments, the fitness of heterozygotes for irradiated chromosomes was below unity fitness. It did not deviate from unity in the control experiment.

Attempts were made to increase the yield of induced mutations without increasing the proportion of aberrations among them. It was found that the viability coefficients of heterozygotes for irradiated chromosomes were increased and the effect was most pronounced just in those series where more detrimental mutations were induced. Yet, indirect tests of the viability of heterozygotes for the induced mutations suggested that the detrimental effects were not completely hidden in heterozygotes.

Extensive experiments were carried out to determine whether preferential segregations of the Cy pr marker chromosome occurring in males could account for the apparent conflict. The experiments suggested a slight preferential recovery of the marker chromosome such that it could bias the results in viability.

The mean fitness of heterozygotes for lethals was reduced by about 7.0% per generation. Subvitals were defined so that they overlapped the normal range, yet their fitness in heterozygotes was reduced by about 2% per generation. Normal chromosomes in the irradiated samples did not deviate from unity fitness. The results show that on the average the fitness of the heterozygotes for a sample of newly induced mutations is correlated with the viability of the homozygotes.

These results suggest that the genetic variants found in nature must be very biased samples of those arising by mutations. Therefore, if an important contribution to genetic polymorphism in nature is due to over-dominant mutations, it is due to a highly selected sample of mutations.

(03 98 009)

Systems of production management

A. Beef Cattle

1. Beef production from dairy animals. In dairy beef investigations at Madison, Wisconsin, calves fed at a medium energy level are gaining at 70-80% of the rate for the high energy groups. Feed consumption per 100 lb. of gain appears to increase with size of animal and energy level. The acetate to proportionate ratio decreased and percent lactic acid increased in ruminal samples as energy level increased.

At Beltsville, Holstein calves gained more rapidly than Jersey, Milking Shorthorn, and beef steers on all feeding treatments. Steers fed the higher concentrate ration gained the fastest and were more efficient.
(03 31 005)

2. Management systems. In an Ohio experiment Hereford and Charolais calves and reciprocal crossbreds were produced from the same bulls. One-half of the calves were creep-fed, fattened immediately following weaning and slaughtered at slightly over 14 months of age. The other half were not creep-fed, were wintered, grazed for about 60 days, fattened in the drylot and slaughtered at about 20 months of age.

Differences between systems of management were significant for all traits except birth weight and area of rib-eye. Steers and heifers were not significantly different in weaning weight, carcass grade or tenderness score. Other traits measured were significantly different with the heifers being lighter in weight than steers.

There were significant sex-management system interactions in area of rib-eye, percentage and weight of edible portion, percentage fat trim and carcass length. Heifers produced by the deferred system had a higher percentage of edible portion while the reverse was true with steer carcasses. Although heifers were fatter at the younger age, they appeared to grow more than steers in area of rib-eye and carcass length between 14 and 20 months of age.

Creep feeding increased weaning weight and final condition more when the dams were two-year old first calf heifers than when the cows became more mature. It was also more beneficial during the drier years when pastures were not as abundant. (Ohio NC-1 contributing project).

Studies at Fort Reno, Oklahoma, indicate that when compared to steers and heifers the advantage of bulls in weight gain, feed efficiency and carcass cutability favors the feeding of young bulls to increase efficiency of beef production. Further work with heifers indicated that 12 mg. stilbestrol implants are profitable if the feed supply is likely to produce 0.9 pounds or more of daily gain. At the same location, it was determined that a 100-pound nitrogen per acre application had no important influence on the vitamin A nutrition of heifer calves consuming the pasture.

Small grains (oats, rye, wheat, barley) for winter grazing of yearling steers supported gains of over two pounds per day at Tifton, Georgia. The inclusion of alfalfa meal or Coastal Bermudagrass meal in a high urea supplement improved drylot gains for steer calves but not for yearling steers. Feed intake was greater for the no urea or low urea rations than for the high urea rations. Steers fed cottonseed hulls as a roughage gained as fast as steers fed snapped corn or oyster shells and faster than steers fed Coastal Bermudagrass pellets or peanut hulls.

Studies of methods of producing and feeding Coastal Bermudagrass pellets at Tifton, Georgia, indicate that pelleting grass somewhat less than twelve weeks old and supplementing with protein and energy would be the most economical system.

A combination of small grain grazing and corn silage feeding proved to be equal to either system individually and allows the flexibility that would be needed during seasons when small grain pastures are poor.

A molasses-urea mixture for wintering brood cows is equal to cottonseed meal provided overconsumption is prevented.

Integrated livestock-timber production on intensively managed pastures continues to appear more profitable than for either system alone.

At Front Royal, Virginia, calf gains were not affected by the dams winter silage feeding (grass, corn or apple pomace). The cows maintained body weight better on the corn and apple pomace silages than on grass silage. (03 30 032 3)

Fertility of cows and gains of calves have been increased by the use of seeded pastures of high producing, introduced-grass-and-alfalfa mixtures at Miles City, Montana, during the early spring. (03 30 040)

At Lincoln, Nebraska, heifers fed high energy (19.6 vs. 12.7 kcal of digestible energy per kg. body weight $3/4$ per day) gained more weight, produced heavier calves and exhibited estrus sooner after calving but had more calving difficulties than low energy heifers. (03 30 036)

Cycling heifers weighing 400 lb., held at maintenance for at least 16 weeks and then allowed to gain rapidly for about 12 weeks, reproduced normally and gained as economically as heifers fed to gain about a pound a day at a continuous rate during the same period. Heifers fed a poor quality, 51% forage ration with $2/3$ of the total nitrogen furnished by soybean meal, $1/2$ soybean meal- $1/2$ urea or urea gained equally and consumed equal amounts of feed. Rations had no effects on services per conception, length of gestation, calf birth weight and number of days from calving to first heat. (03 30 027)

B. Dairy Cattle

1. Evaluation of weighing devices for DHIA acceptability. Two proportional sampling devices, the Milko-scope and Bodmin Milk Meter were tested and found to be unacceptable. The DeLaval rigid-mounted receiver jar No. 8300719-01 was found to provide weights within the tolerances and was accepted as a measuring device when used in accordance with instructions. Data previously collected on a number of other receiver jars by a number of works in various States was analyzed. These data indicated that the companies involved need to make some improvement before their equipment would produce acceptable weights.

Preliminary tests on the Milko-tester (a device for determining percent Bf in milk) indicate that it will provide fat test results to a satisfactory degree of accuracy. Data is being assembled to provide information for a recommendation to the National DHIA Coordinating Group. (03 31 061)

2. Development of allowable tolerances for weighing, testing and sampling devices used in DHIA. Tolerances and specifications for weighing, measuring and sampling devices used in DHIA were developed and accepted by the National DHIA Coordinating Group. These tolerances were based on the following considerations: (1) milking to milking and day to day variation in milk yield and the effect of these variations on the accuracy and precision of estimated lactation production; (2) differences that may be attributed to milking characteristics of individual cows; (3) differences in mean performance that may be due to manufacturing tolerances or operating characteristics of individual milking systems.

The final tolerances adopted by the National DHIA Coordinating Group as a result of this study would accept a device with a weighing error of 10% provided that no bias was present. If the device has a bias, then the allowable error decreases on a sliding scale depending on the magnitude of the bias. No device, however, is acceptable if the bias is as great as 25% of the total error in measurement.

This study has provided objective guidelines for the development of weighing devices. It should have the ultimate effect of increasing participation in dairy recordkeeping. (03 31 061)

3. Dairy recordkeeping programs. The 1,344 dairy herd improvement associations, employing 2,109 supervisors, provide the organizational structure for visiting farms and for reporting data in the 50 cooperating States. The percentage of the Nation's cows enrolled in the National Cooperative Dairy Herd Improvement Program was 21.1%, an increase of 2.0% over the previous year. The number of herds enrolled declined, but the number of cows increased slightly and was as follows:

<u>Plans</u>	<u>Herds</u>	<u>Cows</u>
Standard DHIA	37,683	2,098,919
Owner-Sampler	25,439	825,127
Weigh-a-Day-a-Month	<u>1,001</u>	<u>53,429</u>
Total	64,123	2,977,475

A total of 1,625,509 records of performance was reported to the Dairy Cattle Research Branch for use in the genetic appraisal of cows and sires for research.

The artificial breeding program, through which the superior sires developed and recognized in DHIA herds are utilized, bred a total of 7,286,580 dairy and 647,143 beef cows. This represents 47.9% of the Nation's dairy cows of breeding age, and 1.9% of the beef cows. Both total number of animals and percentage of the Nation's herd inseminated reached an all-time high. The number of AI studs dropped from 44 to 35, but the number of bulls in AI was about the same (2,376 vs. 2,388 in 1965). (03 31 040)

C. Poultry

1. National Poultry and Turkey Improvement Plans. Forty-seven cooperating Official State Agencies reported participation in the National Plans by 12.4 thousand flocks containing 38.2 million breeding chickens and 1.7 thousand turkey flocks containing 4.3 million birds. All flocks qualified for a disease control classification and 92.4% of the chickens and 97.5% of the turkeys were classified under one of the breeding phases of the Plans. The chicks and poults produced by 1,283 chicken hatcheries with incubator capacity of 338 million eggs and 284 turkey hatcheries with capacity for 52 million eggs were officially classified under National Plans standards.

More than 42.7 million birds in 14.1 thousand prospective breeding flocks were blood tested for pullorum disease and fowl typhoid. Only 381 chickens and two turkeys reacted to the tests. Approximately 3.5% of the chicken flocks and 93.5% of the turkey flocks were also tested for M. gallisepticum. Reactors were found in 10.8% of the chicken flocks tested and 2.5% of the turkey flocks. Within the infected flocks 12.3% of the chickens and 10.3% of the turkeys reacted to the test. Approximately 2.0% of the participating chicken flocks qualified for the U. S. M. Gallisepticum Tested classification, which became effective in NPIP in January 1967. This classification, which has been previously effective in NTIP, was attained by 92.8% of the participating turkey flocks. The U. S. Typhimurium Controlled classification was also attained by 87.1% of the turkey flocks.

Cooperating diagnostic laboratories reported only 58 isolations of S. pullorum and 22 isolations of S. gallinarum from poultry specimens. Most of these isolations were from chickens with only one pullorum and three gallinarum isolations from turkeys. The isolations reported represent substantial reduction from the 405 S. pullorum isolations and 164 S. gallinarum isolations reported five years earlier. The reports also show a reduction in the number of isolations of S. typhimurium, but an increase in some other Salmonella serotypes.

Early in 1967 the General Conference Committee of the National Poultry and Turkey Improvement Plans designated selected industry representatives to serve as an Advisory Group for the development of more effective Plans provisions. This Advisory Group recommended changes in the pullorum-typhoid control phase of NPIP to provide for the recognition of disease control practices other than blood testing in the classification of flocks at the multiplier or hatchery supply flock level. The changes would provide for reduction in blood testing requirements as freedom from infection is demonstrated. These changes and others recommended by the General Conference Committee will be considered by the Department for adoption. (03 29 059)

2. Random sample performance tests. Data covering the performance of stocks tested at 13 United States and four Canadian random sample egg laying tests were submitted to the Poultry Improvement office in 1966. These data were combined with that collected in 1965 and analyzed as a two-year performance summary. By combining the data obtained from two years of testing, predictions of the performance of stocks are more reliable than they would be with a single year's data. The two-year data used in the summary covered the performance of 103,199 laying hens representing 80 different stocks. These birds were tested in 1,346 pens at 60 locations in the U. S. and Canada.

The results of these analyses, expressed as regressed means, are predictions of what the performance of a stock would be had it been tested at all 60 locations during the two-year period. The statistical significance of difference was computed for each of the 16 economic traits for each stock, and was expressed as the 90% confidence limits.

Random sample turkey test supervisors submitted individual records on the 2,500 turkeys that were tested at two U. S. locations during 1966. These data represented the performance of 22 stocks that were tested in 42 pens at these two locations. No attempt was made to analyze these data across tests. However, Duncan's Multiple Range Test was applied to 12 traits for each stock to show the statistical significance of difference between entries within a test. (03 29 060)

D. Sheep and Fur Animals

1. Orphan lamb rearing. The use of automatic milk feeders and milk replacer powder in the rearing of orphan lambs starting at one to five days of age was investigated at Dubois, Idaho. Gain per day and consumption of milk replacer powder and creep feed during the nursing period averaged 0.35 lb., 0.42 lb., and 1.10 lb., respectively. The lambs (102 head) were weaned from the automatic feeders at an average weight of 44.5 lb. (73 days average age) and self-fed a pelleted diet during the postweaning period. Average daily gain and feed consumption during the postweaning period were 0.36 lb. and 3.10 lb., respectively. (03 33 014)

2. Performance of early and late weaned range lambs. Performance of 1,544 Rambouillet, Targhee, Columbia and Suffolk sired range lambs from whiteface dams and reared under two management systems (MS) was studied. Lambs in MS-1 were weaned early (85 days) and put into drylot on self-feeders for 22 days (1965) and 14 days (1966). The completely pelleted lamb ration consisted of 62.5% alfalfa-37.5% barley. Next the lambs and self-feeders were moved to irrigated timothy-brome-clover pastures until late weaning (120 days). Lambs in MS-2 remained with their dams on summer range from birth to weaning (120 days).

Feed consumption, body weight gain, mutton type and condition scores were obtained on the early weaned lambs. Similar information was obtained on the late weaned lambs except for feed consumption. Most significant findings were: (1) Average daily gains of early and late weaned lambs were comparable. (2) Late weaned singles gained faster than early weaned singles. (3) Early weaned twins gained faster than late weaned twins. (4) Breed of sire had no significant effect on average daily gain of early weaned lambs but did have significant effect on late weaned lambs. (5) The Suffolk, Columbia, Targhee and Rambouillet sired lambs ranked in the order listed for average daily gains, type and condition scores. (6) Lamb gains in drylot on self-feeders were much better than lamb gains on pasture plus self-feeder. The study is being continued with an added treatment of early weaned lambs remaining in the drylot for the entire period from early to late weaning. (03 33 014)

3. The response of *Artemisia tridentata* and *A. tripartita* to season of grazing. Paddock grazing studies conducted on the spring-fall range at the U. S. Sheep Experiment Station, Dubois, Idaho, have shown that exclusive heavy fall grazing decreases yields of *Artemisia tripartita* and increases yield of grasses and forbs. This response suggests either that spring deferment favors grass and forbs at the expense of sagebrush or that fall grazing damages sagebrush directly. To answer the latter question, we began the first phase of a clipping study on *A. tripartita* and *A. tridentata*.

From May 10, 1965, to April 10, 1966, 80% of the current growth was clipped at monthly intervals on both species. The purpose of this clipping study was to determine whether sagebrush responded differently to clipping in relation to season, particularly during the fall and winter months when sheep will eat 5-20% of it.

The 80% clipping treatments reduced yields of A. tridentata most during July, moderately during spring, and least from late summer through winter months. A. tripartita responded similarly during July, but was damaged least by clipping during the spring. This study indicates that both species of sagebrush can tolerate considerable use during the fall and winter months, but A. tripartita is apparently less tolerant to grazing than A. tridentata. (03 33 012)

4. Management of dry ewes on pasture. Three hundred twenty head of ewes were subjected to three different management systems after weaning of their lambs, until shortly before breeding, in 1966. One group was grazed on good pastures and gained an average of 3.2 kg. per ewe; the second group was grazed on poor pastures and lost an average of 0.5 kg. per ewe; the third group was kept in drylot and fed so as to lose an average of 2.8 kg. per ewe. Percent of ewes lambing was 82.2, 80.7 and 80.3 and number of lambs per ewe was 1.8, 1.6 and 1.6, respectively, for the three groups. Total wool and clean wool production per ewe was 8.7 and 9.3% less for the drylot group than for the two pasture groups. (03 33 011)

5. Grazing sheep and cattle together. Average daily gains of sheep grazing with cattle were 12.2% greater than for sheep grazing alone, during a four year study at Beltsville, Maryland. There was no interaction of this increased gain with year, stocking rate or pasture replicate. Average daily gain decreased significantly as the grazing season progressed and average cumulative daily gains differed significantly among years. Total lamb gain by plot was significantly affected by grazing pressure but not by the cattle to sheep ratio. Total lamb gains were 27.5% greater for the high stocking rate than the low rate. (03 33 015)

6. Forage evaluation. Crownvetch forage has been pastured at Beltsville, Maryland, with sheep at three grazing intensities -- light, medium and heavy -- since May 23, 1967. No ill effects from grazing the forage have been observed. Average daily gains of lambs, from May 23 through July 17, have been 0.20, 0.19, and 0.17 kg./day, respectively, for the light, medium and heavy grazing intensities. (03 33 011)

E. Swine

1. Improve specific management practices and complete management systems to reduce structure costs per unit of output. Four systems of swine housing and waste disposal are being compared at Purdue University, Lafayette, Indiana, to study fly control without the use of insecticides. Type (A) is an open-front, shed-type house with concrete floored front;

types (B) and (C) are enclosed houses with partially slotted floors over pits, but with different methods of waste disposal; and type (D) is an enclosed house with total floor slotted over a lagoon. In (A) the manure and bedding are removed weekly; in (B) and (C) the waste is discharged into a septic tank or a holding tank and later spread on adjacent land; and in (D) the waste is discharged into a lagoon which extends outside the house.

For the first year of operation, fly populations in (B) and (C) were slightly lower than those in (D) and substantially lower than in (A). Mosquito larvae were found in the unscreened lagoons of (D), but none survived in the septic tank lagoon of (B). (03 32 016)

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AREA NO. 409. CONSUMER ACCEPTABILITY OF LIVESTOCK AND
POULTRY PRODUCTS

Problem. Animal products generally have a high degree of consumer acceptability; however, this varies widely among species and products. We should know why. Concern over the role of fat in the diet has focused attention on the problem of excess fat in beef, pork and lamb. Producing animals without this excess fat could save \$1.5 billion in feed costs which could be passed on to consumers in their meat purchases. Per capita consumption trends for milk and eggs point toward possible acceptance problems for these products. More information is needed concerning what livestock product qualities are desired by consumers, and production should be tailored to their preferences and needs for variety and quality.

USDA AND COOPERATIVE PROGRAM

A. Beef Cattle

This program is conducted by food technologists, animal husbandmen, chemists, and statisticians engaged in both basic and applied research. It is designed to determine those factors of growth, nutrition, breeding and management which contribute to the initial quality and quantity of the final product -- meat. Current work involves studies on growth and maturity, tenderness, estimating carcass traits from indicator cuts and live animal characteristics, sex effects on carcass characters and chemical composition of the carcass as influenced by genetic and environmental variations.

The program is an integral part of breeding, nutrition and management studies. It is carried on at Beltsville, Maryland, at six Federally owned field locations, each operated cooperatively with the State in which located, and in cooperation with a number of State experiment stations having projects in regional breeding. A contract with the Wisconsin Agricultural Experiment Station on carcass characteristics of beef and dairy animals managed under different systems is included.

B. Dairy Cattle

The program in dairy cattle is confined to research on dairy beef and milk composition. The milk composition studies involve gamma casein variants and the genetics of milk constituents and has practical application in some dairy manufacturing operations.

C. Poultry

Poultry has no program in this area at present.

D. Sheep and Fur Animals

This is a continuing program conducted by food technologists, bio-chemists, physiologists, animal husbandmen, biologists, and wool and fiber technologists engaged in basic and applied research to evaluate and improve quality of lamb meat, wool and fur. Research on lamb is directed at the influence of breeding, selection, nutrition and management on lamb carcass and meat quality and quantity. Studies are conducted to determine the physical, chemical and biological structures and properties of skin, wool, fur and other animal fibers as influenced by development, growth and other production factors. This work is conducted at Beltsville, Maryland, Dubois, Idaho, and Ithaca, New York.

E. Swine

The swine program in this area is concerned with carcass composition and color of pork. Selection for high and low backfat is being practiced in Duroc and Yorkshire lines of pigs.

F. Broadly Based

This research consists of the meats investigations that are not specific to a single class of livestock. It is mainly on carcass composition, tenderness and other meat quality factors.

The total Federal effort under Area No. 409 by AH is 9.1 SMY intramural and 0.6 SMY extramural distributed as follows: beef 3.6 SMY intramural and 0.6 extramural; dairy 1.0 SMY intramural; sheep and fur animals 2.8 SMY intramural; and swine 1.7 SMY intramural.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State stations in this area totals 43.3 SMY which are distributed as follows: beef 15.9; dairy 5.7; poultry 5.2; sheep and other animals 9.1; swine 6.3; and cross species 1.1.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Beef Cattle

1. Growth and maturity. Studies on growth and maturity in beef steers from six months to seven years have reached the 24 month age. The data show that increases in weight of muscles, bones and lean have started to plateau in the full-fed steers. The muscles from animals on a restricted ration continue to increase but at a slightly slower rate. The animals on restricted plus full feeding the last 180 days are now more truly intermediate between full fed and restricted steers in weight of muscles, bones and other measures of growth. The total weight of the lean and the fat in the half carcass is nearly equal in the 24 month full fed animals. Those

on the restricted ration show the lean to be continually laid down slightly more rapidly than the fat. Again, those animals restricted then full fed are intermediate. The chemical analysis of the individual muscles show those from the full-fed steers to be continuing to deposit intramuscular fat more rapidly than the restricted. Also, the restricted with full feeding the last 180 days are intermediate, but more closely comparable to the restricted group. This is not the case with the separable fat, indicating the fat is being laid down on the outside of the muscles. (03 99 001)

2. Tenderness. Studies of some of the physical responses of muscle fibers of selected beef muscles, the relative contribution of the muscle components, and intramuscular connective tissue to the total toughness of muscle tissue, raw or heated at several temperatures, were continued. The sternomandibularis muscle in the neck region was used. The results of this study indicate that tensile strength of muscle fibers correlated well with shear values ($r = 0.78$); connective tissue contributed to tensile and shear strengths of muscle with estimates of 74 and 78% contribution; intact tissue is closely related to strength of its connective tissue; at 40° C., the tensile and shear strengths of intact tissues are almost entirely that of connective tissue, 94 and 103%, respectively; and above its initial thermal shrink temperature, connective tissue of sternomandibularis muscle loses part of its strength and the denatured fibular and sarcoplasmic proteins exert a greater influence on meat toughness. This work was conducted at the Low Temperature Laboratory, Cambridge, England. (03 99 001)

The data from 99 beef longissimus dorsi muscle biopsy samples were analyzed to determine if a calfhooed biopsy sample when heated would reflect the tenderness of the meat at the time the animal reached slaughter weight and to estimate the effects of diet on tenderness of beef. A biopsy sample 2 x 2 x 6 cm. was surgically removed from steer calves at either 6, 9 or 12 months of age. The calves were then allowed to complete their finishing periods. The biopsy sample after being chilled for 48 hours was deep-fat cooked at 135° C. and tested objectively for tenderness. Except for those calves biopsied at 9 months, there was little or no relationship between objective tenderness of the biopsied sample and the panel or STE of the regular 9-10-11 rib sample cooked and tested in the normal manner. There was a low positive but significant +.38 correlation between biopsied samples from 9 month old animals and the samples from the finished animal. Calves fed milk during the first six months had lower shear values than those on milk replacer, but this treatment effect was masked by later dietary treatments. (03 99 002 and 03 31 057)

3. Estimating carcass values from indicator cuts and live animal characteristics. In a study of 216 Hereford steers, carcass weight and trimmed retail cuts from the round proved to be the best single estimators of kilograms of retail cuts. Prediction equations were developed using carcass weight, trimmed retail cuts from the round, longissimus dorsi area, measures of fat thickness at the 12th rib, untrimmed round weight and weight of kidney, heart and pelvic fat in various combinations. Eighty-

four to ninety-four percent of the total variation in actual kilograms of retail cuts could be accounted for by using these equations. When these equations were tested on the actual cut-out data from another 114 head of Hereford steers, the predictive accuracy was equal to that obtained in the data from which the prediction equations were derived. (03 30 020)

Michigan studies confirm previous evidence that loin-eye area is not a good indicator of percent preferred cuts ($r = -.40$). When carcass weight was held constant, the standard partial regression of percent preferred cuts on loin-eye area was .07. A correlation of $-.77$ was found between percent preferred cuts and carcass weight. The regression of percent preferred cuts on carcass weight has increased in absolute value from $-.007$ in the early years of the project to $-.014$, based on a within-year analysis for the 1964-66 calf crops. There continues to be a slight negative correlation between adjusted percent preferred cuts and tenderness index ($r = -.06$). For the past five years the correlation between pounds of preferred cuts and carcass weight was above .95. Thus, selecting for heavier cattle would be essentially the same as selecting for weight of preferred cuts. (Michigan contributing NC-1 project).

A "Meat index" has been developed in California based on rump shape (essentially roundness of rump) and visibility of creases between muscles in the rump and round region of the live animal. Correlations of the index with percent of nonfat carcass has been high in preliminary studies. (03 30 011)

A study was made of the relationships among the fatty acid content of intramuscular beef fat and animal performance, carcass scores, and meat quality. The highest correlations were found between the fatty acid content of the intramuscular fat and flavor and tenderness. The longissimus dorsi content of oleic acid ($C_{18}^{1=}$) was significantly correlated with flavor score (0.50). The stearic acid (C_{18}) content was negatively correlated with flavor score ($-.35$). High correlations were found between tenderness and the content of C_{14} , C_{16} , and $C_{18}^{1=}$. The multiple correlation between the content of C_{14} , C_{16} , and $C_{18}^{1=}$ and flavor score was .52. The multiple correlation between C_{14} , C_{16} , and $C_{18}^{1=}$ and tenderness was .50. (Hawaii contributing W-1 project).

4. Sex effects on carcass characters. Comparisons of bull and heifer carcasses indicated that bulls produced leaner, trimmer carcasses with slightly larger rib-eye areas. The average fat thickness over the 12th rib of the bull carcasses was less than half that of the heifers and bulls and also had less pelvic and kidney fat. Bulls consistently yielded higher percentages of trimmed retail cuts (5% more) and 10% more total freezer meat along with 1% more bone trim and nearly 10% less fat trim than heifer carcasses. Heifer carcasses graded higher, and taste panel evaluations showed steaks from heifers to be more flavorful, juicier and more tender than those from bulls. (03 30 023)

5. Carcass chemical variations and their genetic and environmental control. In the Western Regional Beef Cattle Breeding Project, W-1, blood serum and 12th rib cuts have been obtained from 482 beef cattle from nine stations. Detailed lipid analyses have been made.

In looking at the data on an individual animal basis it was noted that the compositions of subcutaneous fats were quite similar, not only between animals, but also between stations, whereas the fatty acid composition of intramuscular and serum lipids are widely variable between animals, stations and lipid classes. It appears that subcutaneous fats, being primarily a storage tissue, are relatively independent of genetic control and environmental influence. Intramuscular and serum lipids may respond more to selection and environmental treatment. In addition to the expected large differences in the fatty composition of the various lipid classes, the differences between the inner and outer layers of subcutaneous fat are of interest. A difference of almost four units in iodine numbers is quite large and is accounted for almost entirely by the three 18 carbon acids. This brings up the question as to why the two layers, which presumably have the same function, are so different chemically. Also, which layer is laid down first and which one is mobilized more readily? The answers to these questions may have a bearing on the production of beef with less outside waste fat. (03 30 023)

B. Dairy Cattle

1. Milk constituents

a. Gamma casein variants. In cooperation with workers at the Eastern Utilization Laboratory, studies of variation in γ -casein were made. Disc-gel electrophoresis in four molar urea revealed three γ -casein phenotypes A, AB and B. Milk samples from 165 cows were typed and 87 were A, 65 were AB, and 13 were B. The B type of γ -casein occurs only in milks containing β -casein B. Although the data collected so far are not sufficient to allow analysis of segregation patterns, the association between γ -casein and β -casein indicates a genetic basis for the γ -casein variation. The locus symbol γ_{Cn} is tentatively proposed for use in designating the polymorphism in γ -casein. If control is by codominant alleles, as suspected, they would be designated $\gamma-Cn^A$ and $\gamma-Cn^B$. (03 31 002)

b. Genetics of milk constituents. Previous observations indicated that the genetic type of α_{s1} -casein in milk might affect the curd. Skim milks differing in α_{s1} -casein type were inoculated with starter and renneted. Time to reach pH 5.0 and 4.8 was recorded and toughness of the curd was measured at both pH's. Nine Holstein cows of the following phenotypes were used: 1 A, 3 AB, 3 B and 2 BC. Numbers were limited by the rarity of the A and C genes. Milk from cows of the same type was pooled. The study was repeated eight times over a period of four weeks. Analyses of covariance, with SNF as the independent variable, revealed that A milk

was significantly slower than B and BC in reaching pH 4.8 ($P < .01$). Adjusted means, in minutes, were as follows: BC 289, B 290, AB 304, and A 314. All differences in curd toughness were significant except between AB and B at pH 5.0. The curd was soft with α_{s1} -A while C was associated with toughness. Adjusted means, in grams of force to cut the curd, were: pH 5.0, A 1, AB 19, B 23, BC 119; pH 4.8, A 5, AB 55, B 81, BC 128. The grams of separator "slime" per 454 g. of milk separated was also recorded. Adjusted means were BC .08, B .13, AB .21 and A .47. All differences between types were highly significant. These results, though based on only a few animals, indicate that type of α_{s1} -casein may be of practical importance in some dairy manufacturing operations. (03 31 002)

C. Poultry

1. Control of eggshell pigmentation in Japanese quail. A histological study was undertaken to determine the identity and compare the distribution of eggshell pigment within uteri of wild-type and mutant white-egg quail hens. The histological structure of the quail uterus is very much like that of chickens. The epithelium lining the lumen is composed of a single layer of alternating apically and basally oriented cells. Beneath the epithelium is an area of coiled tubular glands which open directly to the lumen through the overlying epithelium. This region has a rich vascular supply with many capillaries lying immediately below the epithelial basement membrane. The peripheral area of the uterus is a zone of muscle and connective tissues bounded at the outer margin by peritoneum.

With ultraviolet light microscopy, the uterine tissue from hens of both phenotypes killed before superficial pigment deposition exhibited red to orange fluorescent granules nearly filling the cytoplasm of apical cells. Many mutant apical cells were devoid of fluorescent granules. Fluorescence in mutant tissues was less intense than wild-type and faded rapidly on exposure to ultraviolet light. Intensely brilliant, homogeneous, and long-lasting red fluorescent spheres were present in the cytoplasm of many mutant apical cells. Cells with a few red and yellow fluorescent granules were frequently observed in the subepithelial capillaries and connective tissue of mutant uteri. Sections from hens of both types killed after superficial pigment deposition contained much less granular fluorescent material. The number and fluorescent intensity of the spherical bodies in mutant tissues were undiminished, and, possibly due to the less intense granular fluorescence, a few such structures could be seen in wild-type tissues. With the ordinary light microscope, the uterine epithelium of wild-type hens killed before superficial pigment deposition exhibited heavy accumulations of granular and diffuse brown pigment in the apical cell cytoplasm. The uteri of mutant hens exhibited much less of this but contained many spherical bodies of deep reddish-brown pigment, the location of which corresponded exactly with the red spheres observed in ultraviolet light. Large areas devoid of all pigment were common in mutant uteri but never were observed in wild-type. The density of apical cell cytoplasmic pigmentation was greatly reduced in uteri from wild-type hens killed after superficial

pigment deposition. Apical cells with pigmented cytoplasm were rare in mutant uteri but the spherical cytoplasmic pigment bodies noted before remained very common.

At no time in this study was pigment detected in apical cell nuclei, basal cells, tubular glands, or on the free surface of the epithelium.

The red autofluorescence in both wild-type and mutant uterine sections positively identifies intrauterine eggshell pigment as ooporphyrin. The deficiency of granular ooporphyrin in mutant apical cells corresponds with a similar pigment deficiency on mutant eggshells. The almost complete restriction of spherical pigment bodies to mutant tissue suggests that the physical characteristics of mutant and wild-type intrauterine pigment are somewhat different. Reduction of ooporphyrin density in apical cells of both phenotypes following superficial pigment deposition, together with the fact that free masses of pigment have never been observed in the uterine lumen, establishes a fundamental, active role for the quail uterine epithelium in production and deposition of eggshell pigment. The findings of this study recommend a reexamination of earlier theories which suggested that the pigment on speckled birds' eggs was produced either by the tubular glands or in more cranial portions of the oviduct. (03 29 022)

D. Sheep and Fur Animals

1. Effect of management system on carcass merit. Eighty head of lambs were raised under two systems of management (at Beltsville, Maryland, in 1966) from weaning until they reached slaughter weight. Forty-one head were individually self fed in pens with raised screen floors and 39 head were grazed on pasture. The pasture lambs received creep pellets ad libitum. All lambs were slaughtered one week after reaching a body weight of 45.4 kg. Slaughter grade, carcass grade, dressing percent, yield of untrimmed primal cuts and ether extract of the ground entire right side of the carcasses were significantly higher for the individually-fed lambs ($P < 0.01$). Excess fat on primal cuts also was significantly higher ($P < 0.05$) for the individually-fed lambs. Crude protein content of the ground right side of the carcasses was higher for the pasture fed lambs ($P < 0.01$). Weight of trimmed primal cuts, age at slaughter, Warner-Bratzler shear values on leg and loin and overall desirability of the meat (taste panel) were not significantly different for the two groups. Correlations between crude protein and ether extract in the ground right side of the carcasses were -0.90 and -0.91. Average daily gain of the individually-fed lambs ranged from 0.138 to 0.382 kg./day and feed efficiency ranged from 4.97 to 11.15 kg. of feed per kg. of gain. Correlation between average daily gain (ADG) and feed efficiency was -0.87. Correlation between ADG during the test and ADG until weaning was -0.008. (03 33 001 and 03 33 002)

2. Predicting body composition from live animals. Study of methods to accurately predict live animal body composition was continued using sheep as the experimental animal. The purpose of this experiment was to measure

the potassium space in the animal, and to find what effects changes in ration would have on the estimate of space. Four sheep were assigned at random to a 4 x 4 Latin square experiment. Each animal received an oral dose of ^{42}K with each of four rations of grain to hay. Upon completing the feeding trials the sheep were slaughtered and the bodies ground and sampled for proximate analysis.

Balance data indicated that the experimental animals remained in a negative sodium balance as long as hay constituted a part of the ration. A fecal loss of sodium occurred even in a negative sodium balance. A positive potassium balance was shown for all animals even on the all-grain ration. The administered isotope appeared to attain equilibrium among various excreta and rumen samples just prior to the 48 hour period. More than 10% of the total dose of ^{42}K was lost in the feces with the all-hay ration, but as the ratios of hay:grain decreased, the total percent of the ^{42}K loss in the feces attained a lower, more constant value. These results would suggest that experiments involving potassium space estimates in ruminants by the isotope dilution technique be carried out under conditions of standardized electrolyte intakes, preferably at potassium dietary intakes when potassium losses in the urine and feces remain at a constant low level. (03 33 027)

3. Quality of lamb meat. Study of factors affecting flavor of lamb meat samples was conducted over a two-year period. Two-hundred two lamb leg and loin samples representing ram lambs from six breeds and their crosses were used. The left leg and loin samples were heated and tested for intensity and desirability of flavor of fat and lean, tenderness, quality and quantity of juice, overall desirability by a trained panel and objectively for tenderness. The loin-eye muscle from the right side was analyzed for ether extract fat. A preliminary study of the statistical analysis of the data shows that for the entire population a rather high interrelationship exists between intensity and desirability of flavor of fat, lean, quality and quantity of juice, overall desirability, and to a lesser extent, tenderness. Intramuscular fat of the loin-eye muscle had little or no relationship to factors of importance in evaluating eating quality. This was not true for individual breeds as percentage ether extract fat was associated with desirability of lean, quality of juice and overall desirability. A least squares analysis of variance for the 65 purebreds indicated there was a year effect for tenderness and intensity of fat and lean. (03 33 027)

4. Measuring methods to evaluate wool. The Electronic Fiber Fineness Indicator (EFFI) which has been designed to measure fineness and variability of wool has been used to measure 93 samples of wool top, ranging from 17 to 37 microns in average diameter. The same tops have been measured by the standard short fiber method at Beltsville and at two commercial laboratories. Difficulties are encountered in the instrument because it records some particles which are not wool fibers and records some fibers which are adjacent to each other as one large diameter fiber. Inspection of the results of diameter by EFFI and the three laboratories indicates fairly

good agreement. Analysis of the data is partly done. Placing EFFI on the same basis as the short fiber method -- 2.5 micron increments from 10 to 70 microns instead of 1 micron increments from 1 to 100 -- gives better agreement. More detailed analyses will pinpoint the doubling of fibers through comparisons of variability by both methods.

The rotary cutter which has been under development at Beltsville has been completed. It is now being used to cut fibers for diameter and variability determinations in the Model "C" Coulter Counter. Lengths and variability of length of fibers is being determined on a within-cut and between-cut basis for this instrument as well as for two other cutting methods. Analyses have been completed for one method, showing that variation between cuts is considerably less than within cuts. Since many cuts are necessary to obtain a sample, this factor is important. A check of the data now being obtained indicates that the rotary cutter will produce less variable lengths within and between cuts than other cutting methods available. (03 33 018)

5. Relation of fleece traits to processing characteristics. Analysis of data is being continued on the relationship among various wool traits, yield and quality of top on 14 breed-grade lots each containing 15 mature ewe fleeces obtained each year for six years at Dubois, Idaho. Preliminary analyses show that Rambouillet wool was significantly shorter, finer and more crimped than Targhee wool of the same visual grade. Differences in top yield and noil yield from Targhee and Columbia wool visually graded the same were not significantly different. (03 33 019)

E. Swine

1. Selection for low and high backfat. Selection for high and low fatness at a live weight of about 175 lb. has been carried through 12 generations in Durocs and 10 generations in Yorkshires. Backfat thickness now differs by about 1.23 inches between the high and low fat Duroc lines and by about 0.78 inch between the high and low fat Yorkshire lines. Relative to the foundation populations from which the lines were developed, the difference between the Duroc lines represents a 57% increase in the high fat line and a 26% decrease in the low fat line. The corresponding values for Yorkshire lines are 39 and 23%, respectively. Realized heritabilities based on data collected through the first 10 generations for the Duroc lines and the first 8 for the Yorkshire lines were 0.47 and 0.48 for the high and low fat Duroc lines and 0.38 and 0.43 for the high and low fat Yorkshire lines. Adjustment of the data for differences in date of birth and pig's inbreeding reduced somewhat the asymmetry in selection response shown by the high and low fat Duroc lines during the first half of the experiment but failed to do so in the case of the Yorkshire lines. Estimates of heritability from regression of offspring on midparent means were generally in good agreement with those based on selection responses. These results suggest that epistatic and/or maternal effects contributed little, if anything, to the variation in backfat thickness. (03 32 002)

Carcass data obtained on samples of pigs slaughtered at about 210 pounds show that low fat Durocs yielded about 16 pounds more in lean cuts and about 21 pounds less in fat cuts than the high fat Durocs. The respective differences between high and low fat Yorkshires were 10 pounds for lean cuts and 14 pounds for fat cuts. Line differences in length of carcass, percent bacon, and loin-eye area were of about the same magnitude as for pigs of 1965 farrow. As in 1965, low fat Duroc pigs averaged about 0.5 more vertebrae and one more rib than high fat pigs, with controls slightly exceeding low fat pigs in both traits. There was little or no difference in number of vertebrae or number of ribs between high and low fat Yorkshire pigs. (03 32 002)

2. Genetic parameter estimates. Data collected on 585 pigs from 116 sires of five different breeds were used to evaluate the effects of breed and sex on 17 measures of carcass quality and to obtain estimates of genetic parameters for these traits. Breed differences were significant for all traits. Gilts averaged higher yields of lean cuts, larger loin-eye area, and less backfat than barrows. Lean cuts of barrows had more intramuscular fat as shown by significantly higher marbling scores and ether extract values. Also flavor scores, probably due to higher intramuscular fat, and firmness scores were higher in barrows. For other measures of carcass quality sex differences were not significant. (North Carolina)

The heritabilities of percent lean cuts, backfat thickness, loin-eye area, ether extract, total moisture, expressible juice, and taste panel scores for fatness and flavor were estimated at .40 or above. Data on juiciness, color, shear value, meat film area, and softness scores gave heritabilities between .20 and .40, while data on pH, marbling, weeping score, and juiciness score gave estimates below .20. Estimates of genetic correlations indicated that backfat thickness, loin-eye area, and percent lean cuts were favorably associated with each other but were unfavorably associated with overall quality of the meat. Thus, simultaneous selection for both quality and lean content is indicated if pork quality is to improve as lean content is improved. (North Carolina)

3. Genetics of muscle traits. A study of eight muscle traits in 142 Duroc and Yorkshire barrows showed that Yorkshire had significantly higher values for color and gross morphology score, 24-hour pH, myoglobin concentration, fiber diameter and percent moisture, while Durocs significantly exceeded in initial glycogen content and ether extract values. Expressible juice values did not differ significantly between breeds. Phenotypic correlations among these traits were in general agreement with other reports. However, the correlations of initial glycogen content with color and gross morphology score, as well as those of fiber diameter with ether extract and with percent moisture, differed significantly between breeds. These results suggest breed differences relative to the site of lipid deposition in the muscle. All heritability estimates and most of the genetic correlations for the traits studied were nonsignificant but had wide

confidence limits due to the small number of observations. The limitations of these genetic estimates as they are influenced by sex, breed, and strain were considered. (03 32 024)

4. Color of pork. Research on color in pork (pale, soft and exudative) as related to and/or controlled by physiological factors, as a PL 480 project with Poland, was started. Preliminary findings confirm earlier reports that a pH value of 6.3 or higher is necessary for good normal meat sensorial appraisal, and values lower than 6.0 for PSE meat, with intermediate being of medium quality. Detailed assay of the protein fraction shows that pale and watery structure of meat is conditioned significantly by lower solubility of sarcoplasmic and myofibrillar proteins and particularly by the presence of denatured protein. Incidence of PSE meat appears to be associated to a high degree with energy level of nutrition. Etiology studies show no relationship of PSE meat and vitamin E deficiency. (03 32 029)

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AREA NO. 701. ANIMAL PRODUCTS FREE OF TOXIC RESIDUES

Problem. Research on toxic residues of agricultural origin is needed to determine the circumstances under which a particular pesticide may be safely used in crop or livestock production. There is widespread public concern as to the nature and seriousness of the hazards caused by the use of pesticides in the production of farm products. Livestock and poultry producers are especially concerned, because chemical residues in meat, milk and eggs often result from animal consumption of contaminated feeds rather than direct usage of pesticides in animal production. Farmers have a vital stake in the detection and elimination of these hazards because of their possible effects on human health, the resulting hesitancy on the part of consumers to buy animal products, and the income loss that may occur if products are not acceptable.

USDA AND COOPERATIVE PROGRAM

A. Beef Cattle

Studies in beef cattle are oriented toward residue accumulation and distribution in animal tissues and the pathways of absorption and excretion.

B. Dairy Cattle

Dairy cattle research in this area is aimed at finding ways to handle or feed pesticide contaminated forages so that objectionable residues in the milk are eliminated or minimized. Insecticides which can be fed in order to make the resulting feces toxic to fly larvae are being studied. Physical methods of controlling flies are being investigated with the cooperation of the Agricultural Engineering and Entomology Research Divisions.

C. Poultry

All pesticide research in the Poultry Research Branch is extramural. Research contracts are in effect with Iowa State University, Ames, Iowa, (three years, 1965-1968) to study malathion residues in poultry meat and eggs; with the University of Georgia, Athens, Georgia, (three years, 1966-1969) to investigate procedures to accelerate the elimination of DDT residues from eggs and body tissues of hens; and with Ohio State University, Columbus, Ohio, (three years, 1967-1970) to determine the pesticide content of chicken feedstuffs, including corn, soybean meal, alfalfa meal, fat, and fish meal and the effect of these pesticides on residues in poultry meat and eggs.

D. Poultry and Swine

A contract has been initiated with the Battelle Memorial Institute, Columbus, Ohio. The project is entitled "The development of antibiotic resistance in enteric microorganisms in chickens and swine." It has a duration of one year (1967-1968) at a cost of approximately \$50,000.

E. Swine

This is a continuing program conducted by nutritionists and animal husbandmen. The object is to investigate basic problems that may result from the use of feed additives which may be toxic to swine or result in residues in pork. Work is in progress at Beltsville, Maryland, in cooperation with the Human Nutrition Research Division.

F. Broadly Based

This research is on the basic metabolism, fate and role of agricultural chemicals ingested by livestock and poultry. It is conducted at the Metabolism and Radiation Research Laboratory, Fargo, North Dakota, in cooperation with the Entomology and Crops Research Divisions.

The total Federal effort by AH in Area No. 701 is 11.3 SMY intramural and 4.5 SMY extramural distributed as follows: beef cattle 0.6 SMY intramural and 0.1 SMY extramural; dairy cattle 2.0 SMY intramural and 2.4 SMY extramural; poultry 1.0 SMY extramural; swine 0.7 SMY intramural and 1.0 SMY extramural; and broadly based 8.0 SMY intramural.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State stations in this area totals 5.0 SMY.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Beef Cattle

Fat depot DDT residues resulting from feeding cows apple pomace were below the legal tolerance, reflecting a lower residue level in the pomace as compared to levels in earlier studies at Front Royal, Virginia. On this basis DDT residues in tissues of cows fed apple pomace should not pose a problem, particularly if apple producers continue to use less DDT in their pest control programs. Future studies are planned to study other residues in apple pomace such as tedion and kelthane.

Work is underway for developing procedures for cannulating the portal and ruminal veins of beef animals to investigate the site of absorption of pesticides from the bovine digestive tract. There are difficulties in maintaining the cannulas.

Studies of the quantitative measurements of the fate of pesticide residues in beef cattle are being initiated using radioisotope techniques. Equipment for the total collection of animal excreta and respiratory CO₂ has been constructed and will maintain animals in a normal physiological state, based on respiratory and electrocardiogram patterns and body temperature measurements, over a five hour respiratory collection period. The CO₂ collection system has been standardized and 90% of the C¹⁴O₂ introduced into the chamber is collected within the first hour. A recovery pattern of C¹⁴O₂ from C¹⁴ labeled glucose has been made.

Heptachlor dissipation rates were linear ($b = -0.0173$ ppm/wk) over a 411-day period and no differences were found due to nutritional treatments in studies conducted at Front Royal, Virginia.

B. Dairy Cattle

1. Reducing pesticide residues in milk and meat

a. Evaluation of a new insecticide for alfalfa weevil control.

GS13005 is an unnamed organic phosphate which holds considerable promise for the control of alfalfa weevil. Since this is an important forage crop, information is needed that will identify the fate of residues when they appear on forage crops fed to dairy cattle. These investigations are being carried out at VPI on a contract basis. It has been found that the inclusion of about 30 ppm of GS13005 in feed produces a distinct toxicity symptom in calves. During the last year the technical material has been fed to lactating dairy cows at levels corresponding to 30, 14 and 7.5 ppm of the total ration. These treatments have failed to produce any observable toxic symptoms nor has there been any detectable level of material in the milk produced. Analyses of the fecal, urine, and tissue samples obtained in this study are presently underway. Since the expected crop residue levels from recommended spraying procedures would result in forage containing less than 1.0 ppm, the outlook at the present time for the eventual practical use of GS13005 is favorable. (03 31 069)

b. Uses for dieldrin contaminated hay.

Large amounts of dieldrin contaminated forage are produced in those areas having had a long history of dieldrin spraying. How to safely use these forages in a dairy ration presents a considerable problem. The possibility of feeding contaminated hays during the dry or prepartum period in order to avoid milk contamination was studied. Heifers were fed .11 mg. dieldrin per kg. body weight for 60 days starting at 60, 120 or 180 days prepartum. After calving, dieldrin levels in the body fat were 10, 17 and 32 for the treatments, respectively. Dieldrin in the milk fat produced by these animals at freshening time was 20, 21 and 28 ppm in the fat. After a milking period of 24 weeks during which a no residue ration was fed, the groups previously fed at the 120 and 180 day prepartum point had excreted about 2 1/2 times more dieldrin in the milk than had the group in which feeding started 60 days prepartum. Placental transfer of dieldrin was observed in all the calves examined. In

all cases, milk was the major excretion pathway for dieldrin and only 2.5% of the dieldrin fed appeared in the feces and essentially none in the urine. At present, it appears that feeding of dieldrin containing forage during the dry period is not a way to circumvent the problem of milk residues since the residues will eventually appear in milk. (03 31 023)

c. Excretion patterns of heptachlor. The problem of heptachlor residues in forages is similar in many respects to that of dieldrin, but is acute in a different geographic area. An investigation of methods whereby heptachlor-containing hay might safely be fed has been underway at the University of Maryland under contract. Additions of organic calcium salts to the ration had very little effect on the rate of absorption of heptachlor and level of storage in body fat. Feeding of iodinated casein as a means of "flushing out" the heptachlor residues was generally unsuccessful. Although the level of milk fat production and the excretion rate of heptachlor were increased by iodinated casein, the unfavorable physiological effects on the animals seem to preclude this as a method of fast clearance of the animal body. Similarly, ethoxyguin was unsuccessful in altering the pattern of heptachlor excretion. Additional vegetable or animal fat in the concentrate ration increased somewhat the absorption of heptachlor. Cyclic feeding, or feeding at different levels of energy intake while it had some marked effects on production levels, had little effect on the overall pattern of heptachlor residue excretions. Feeding of the contaminated hay during the dry period simply resulted in the accumulation in body fat of heptachlor which was subsequently excreted as a milk residue. There appears to be no optimum time during which one can feed this contaminated hay nor as yet has there been any method evolved of feeding the hay in such a way that heptachlor absorption would be reduced. The general level of residues in the milk seem to be very closely associated with levels of residues in the body fat and/or the level of heptachlor feeding. (03 31 028)

d. Metabolism of DDT, DDD and DDE. Two cows were dosed with crystalline DDT about 30 days before calving. The amount and level of DDT and DDE excreted for about 50 days postpartum was closely associated with the level and amount of milk fat secreted. However, the excretion pattern of DDD more closely resembled the pattern of body energy loss, DDD excretion being markedly reduced as the cows returned to energy equilibrium. These findings indicate that the values of DDT and its metabolic products should be considered separately if full understanding of the excretion pattern is to be obtained.

Sixteen cows were used to compare the effect of various levels of dietary fat and concentrate intake on secretion of DDT and its metabolites into milk. Neither of the treatments had a significant effect. However, the higher fat levels did lower the ratio of DDD to DDT indicating that fat may reduce the conversion of DDT to DDD. DDD accounted for about 80% of the total residue in milk when DDT was fed. The DDD concentration in milk fell rapidly after DDT feeding stopped and it was less than the DDT concentration within five days.

In vitro fermentation studies show that rumen microorganisms can rapidly dechlorinate DDT. The primary product formed was DDD and there is some evidence that the DDD can be degraded more slowly. Approximately 90% of the DDT was degraded in five hours and over 98% in 48 hours.

It is common practice to sum the values for DDT, DDD and DDE when expressing the level of DDT contamination in milk. Since DDT is several times more toxic than its metabolites, the level of hazard in milk is clearly overestimated by this procedure. The combined expression can also lead to misunderstandings of excretion phenomena. (03 31 029)

e. Use of MCA-600 on Bermudagrass. Silage from Bermudagrass sprayed with up to four times recommended levels of MCA-600 (a carbamate) was fed as the only forage to Jersey cows at Tifton, Georgia. No detectable levels of residue appeared in the milk after 28 days of feeding. Silage containing up to 90 ppm of MCA-600 in dry matter had no significant effect on silage intake, milk production, cholinesterase activity, plasma carotene or vitamin A. Bermudagrass pastures sprayed with 1.0 lb./acre of MCA-600, were readily grazed by steers the following day. MCA-600 appears to be a very useful and safe insecticide on the basis of these results. (03 31 023)

2. Controlling flies in and around dairy cattle

a. Use of larvicides for controlling houseflies. Inclusion of an insecticide in cattle rations which would make the resulting feces toxic to fly larvae would be a convenient way to eliminate one of the primary fly breeding places on dairy farms. The feasibility of such an approach depends on identifying an insecticide feeding regime which would not produce milk or meat residues and would not reduce the nutritive value of the ration.

Results to date with two organic phosphate compounds indicate that Co-Ral at 48 ppm in a complete ration reduced housefly larvae emergency by about 75%. Milk produced under this regime contained no detectable residue. Another larvicide (Shell SD 8447) was nearly 100% effective at 24-36 ppm of total ration. No residues were detected in the milk. These results are regarded as preliminary and implementation of the results will depend on further favorable observations. (03 31 066)

b. Controlling flies without chemicals. At Beltsville, Maryland, investigations of physical methods for control of flies were continued with cooperation of Entomology, Animal Husbandry and Agricultural Engineering Research Divisions, ARS.

Studies of the effectiveness of farmstead sanitation in reducing fly populations were continued and confirmed previous findings that significant population reductions (about 1/3) can be achieved by sanitary means on a single farm when unsanitary farms are as close as 1/2 mile away. Data on recapture of released marked flies indicated that flies disperse primarily upwind and to "dirty" areas with many possible breeding sites, rather than to "clean" areas.

In evaluation trials of existing fly control devices, including electrocutor grids, electrocutor grids plus light attractants, and attractant-toxicant devices (ultraviolet attractant lamps behind a gauze curtain treated with a contact insecticide), all proved virtually ineffective when used outdoors in cattle pens. Numbers of flies killed were insignificant and unlighted grids were as effective as lighted ones, indicating random flight to all units. Three types of attractant-toxicant devices tested inside barns killed slightly larger numbers of flies.

Further tests of the responses of houseflies and faceflies to various wave lengths of electromagnetic radiation indicated type GRO (Gro-Lux) lamps to be more attractive than would be suspected from their appearance to human vision, but less attractive than "blacklight" ultraviolet. When ultraviolet lamps were cycled "on" and "off" for varying proportions of time, the number of flies collected increased as the "on" cycle lengthened, indicating no benefit from cycling. The response of houseflies in a lighted environment to various attractant wave lengths appeared to be affected by both temperature and sex. At low temperatures (65° F.) the catch is predominantly males and longer wave lengths -- green, yellow and orange -- seem more attractive than ultraviolet. At high temperatures (90° F.) the catch is predominantly females and short wave lengths -- ultraviolet and 4000 Å blue -- seem most attractive. Limited tests with infrared radiation indicated that flies readily detected and followed currents of warm air but were not attracted by direct infrared radiation. (03 31 045)

In the first year of a two-year study, mechanical sanitation and mechanical sanitation plus occasional use of residual insecticides were compared to normal fly control practices. This work was done under contract at Louisiana with three farms assigned to each treatment. Elimination of breeding sites by mechanical sanitation apparently prevented the late summer buildup of housefly populations occurring on control farms. Stable-fly populations remained low under all treatments. The study will be continued. (03 31 014)

C. Poultry

1. Malathion residues in poultry products. A study was conducted under contract with Iowa State University of Science and Technology. The results show that malathion accumulates very slowly in the tissues of hens. Administration of 250 or 500 ppm daily, based on feed intake, resulted in no measurable quantities of the pesticide in egg yolk, breast muscle or feces after 21 days.

2. DDT residues in poultry products. In studies under contract with the University of Georgia, hens were exposed to DDT by overhead spray. Unexposed controls were compared with exposed full fed hens and with exposed hens that had been forced to molt by restricted feeding. Fat and eggs from the control group contained measurable quantities of DDT. The forced molt resulted in concentration of DDT in the abdominal fat, compared

to that of the exposed full fed hens. In another trial it was found that levels as high as 5 ppm of DDT based on daily feed intake were not significant to produce residues as high as was desired for the study. Higher levels of DDT will be fed. (03 29 018)

D. Swine

1. Pesticide residues in swine. Three levels of heptachlor (0.014 to 2.8 ppm) and one level each of DDT (34 ppm) and malathion (150 ppm) were fed to swine to determine the effects of ingesting pesticide-contaminated feeds. Additional treatments consisted of feeding a diet containing hay contaminated with heptachlor in the field, feeding heptachlor in the diet combined with five sprayings of malathion at biweekly intervals, and feeding condemned milk from cows fed heptachlor-contaminated hay.

The pesticide treatments had no effect on the health, mortality, or growth rate of the pigs during the 14 week growing-finishing period.

At the conclusion of the 14-week test period, two pigs from each treatment were shifted to the control diet and backfat was biopsied at biweekly intervals for four months. Analysis of the final samples from pigs fed the heptachlor or malathion showed residue levels low enough for them to be cleared for market. The remaining samples are being analyzed to determine the rate at which the pesticide residue levels decrease.

Six gilts from each lot (except the milk-fed lot) were continued on their respective treatments in order to study the effects of the pesticides on reproductive performance. No adverse treatment effects have been observed. Samples of colostrum, five-week milk, and tissues from pigs obtained at birth and six weeks of age are being analyzed by Entomology Research Division. (03 32 017)

2. Prevent toxic residues from feed additive use in growing swine

a. Zinc utilization and metabolism. Balance trials were conducted to determine the effect of zinc level and two chelating agents, sodium phytate and ethylene diamine tetra acetic acid (EDTA), on zinc retention. Urine analyses of zinc and calcium have been completed. Fecal samples are now being prepared for analysis. No conclusions can be drawn on the effects of the two chelating agents on zinc retention until the analysis is completed on the feces. (03 32 019)

E. Broadly Based

1. Herbicides. Studies continue on the metabolic fate of selected triazine herbicides, with particular emphasis on the isolation and identification of their metabolic products. These investigations involve the triazines -- propazine, atrazine and simazine.

Ion-exchange chromatography has demonstrated the qualitative similarity of the metabolism of the triazine herbicides. Simazine yields 17 urinary metabolites which co-chromatograph with 17 of the 19 metabolites found with atrazine. The two additional atrazine metabolites co-chromatograph with two of the 22 metabolites found with propazine. There are approximately five minor propazine metabolites which are not found with either simazine or atrazine. This information has prompted first work on the identification of the atrazine metabolites. (03 99 008)

2. Insecticides

a. Chlorinated hydrocarbons - dieldrin. The first replicate of a factorial experiment designed to study the metabolism, accumulation, and excretion of dieldrin by sheep is nearly completed and the second replicate is underway. Variables include four levels of dieldrin, two levels of energy with two sources of supplemental energy, and five slaughter intervals in a 32-week experiment period.

Analyses for dieldrin, or its metabolites, and fat are made in brain, spinal cord, heart, liver, bile, blood, plasma, adrenals, kidneys, visceral fat, bone (femur), ruminal contents, intestinal contents, feces, urine, and the ground carcass. Analyses are not complete, but the following observations have been made.

Dieldrin fed at a rate of 4 mg./kg. body weight was lethal to ten of 12 sheep by the fourth week. The ability of these sheep to withstand poisoning appeared to be directly related to the amount of fat in their bones, which probably is related to the amount of fat in their bodies.

Administration of radiolabeled dieldrin to selected sheep and subsequent chemical and nuclear analyses have shown that the radioactivity is not completely extractable from bile, urine, feces, kidney, liver, and rumen contents by the dieldrin analytical procedures. For example, the ^{14}C concentration in bile was relatively high, but less than 10% of this activity was extractable in dieldrin solvents. This probably means the bile contains dieldrin metabolites and that this is a pathway of dieldrin excretion. Similarly, less than 10% of the radioactivity of the urine is extractable as dieldrin, but the range of ^{14}C -dieldrin equivalents excreted in the urine is 1 to 15% of the dose. Since only small quantities of dieldrin were found in blood or the spleen, these materials are no longer analyzed. Nearly all of the dieldrin in blood was in the plasma fraction. (03 99 005)

b. Carbamates - Mobam. Investigation of the metabolism and and metabolic fate in animals of the carbamate insecticide, Mobam (4-benzo(b)thienyl-N-methyl carbamate), has been initiated.

Two groups of 14 rats each were dosed with 2.0 mg./kg. and 13.0 mg./kg. of Mobam-¹⁴C as a single oral dose dissolved in 1 milliliter of ethanol. Four rats of each group were sacrificed at 2, 4 and 8 days. Two rats from each of the respective dosage levels were sacrificed at three days for determining total carcass residues. Average values of the two rats used for total carcass residues after three days on each treatment were 6.4 microgram equivalents and 48.3 microgram equivalents of Mobam-¹⁴C for the dosages of 2.0 mg./kg. treatments, respectively. This represents .82% of the 2.0 mg./kg. dose and .92% of the 13.0 mg./kg. dose remaining in the total body (including digestive tract and skin) at the end of three days.

Rats receiving 2.0 mg./kg. of Mobam excreted 87.4% of the radioactivity in the urine and 8.4% in the feces within 24 hours, as compared to 76.2% of ¹⁴C recovered in the urine and 7.3% in the feces of rats receiving 13.0 mg./kg. of Mobam-¹⁴C. At the end of eight days, approximately 100% and 92% of the ¹⁴C activity of the 2-mg. and 13-mg. doses were recovered in the urine and feces. It is obvious that Mobam is readily excreted by the rat and the tissue residues of ¹⁴C are correspondingly low.

Two lactating goats were dosed with 4.6 mg./kg. of Mobam (121.9 microcuries of Mobam-¹⁴C) and with 12.5 mg./kg. of Mobam (121.9 microcuries of Mobam-¹⁴C). At 24 hours the goat receiving 4.6 mg./kg. and the one dosed with 12.5 mg./kg of Mobam had excreted respectively 96.4% and 95.1% of ¹⁴C activity in the urine and 4.8% and 6.7% in the feces. Both goats excreted similar relative amounts of ¹⁴C at similar time intervals, indicating that the higher dose (12.5 mg./kg. did not reach a level of intake which could not be rapidly metabolized.

The goats were sacrificed 48 hours after dosing and tissue samples analyzed for ¹⁴C residues. Since the radioactivity was rapidly excreted, only small residues remained, and those tissues active in metabolism (liver) and excretion (kidney) contained the higher levels of ¹⁴C -- 0.16 and 0.06 ppm of Mobam equivalents, respectively. The rat and goat tissues were comparable as to the level of residues.

Milk from the goat receiving 4.6 mg./kg. had a maximum metabolic content in the eight-hour sample (3.1 ppm) and milk from the goat dosed with 12.5 mg./kg. contained 21.5 ppm and 19.5 ppm in the four- and eight-hour samples, respectively. The levels of ¹⁴C activity in the milk show a similar trend to the levels of radioactivity in the urine. This suggests that blood levels (not determined) are probably highest at these times, as absorption and excretion of metabolites of Mobam would be at a maximum.

Preliminary data obtained from chloroform partitioning of the ¹⁴C in the milk indicate that 5% or less of the radioactivity is organic soluble. Therefore, the radioactivity in the milk probably represents water-soluble conjugates or complexes of Mobam, since both Mobam and 4-hydroxybenzothiophene are organic soluble.

A sulfuric acid ester of 4-hydroxybenzothiophene has been isolated from rat urine and identified by comparing the infrared spectra of this metabolite with an authentic sample of the compound.

Metabolite separation and isolation are in progress. (03 99 003)

3. Feed adjuvants. The metabolic fate of diiodosalicylic acid (DIS) has been determined in the cow and rat with the isolation, identification, and quantitation of the products of DIS metabolism. In three trials with cattle, approximately 95% of the ^{14}C -labeled DIS was excreted in the urine within ten days. The rat excreted approximately 80% of the dose in the urine within 72 hours. Isolation and identification of metabolites were accomplished by column chromatography, gas chromatography, infrared analysis, and synthesis of the presumed compound. The metabolic products found in cattle urine were DIS and 5-iodosalicylic acid, with ratios of DIS:5-iodosalicylic acid varying from 1.1 to 7.8. DIS, 5-iodosalicylic, 3-iodosalicylic, salicylic, and salicyluric acids (the glycine conjugate of salicylic acid) were identified in rat urine. Thus, rats have a greater ability than do cattle to remove iodine from DIS. These data explain why DIS is an unsatisfactory carrier of iodine in trace mineral salt for cattle.

This project has been completed. (03 99 002)

4. Microbiological studies

a. Herbicides

(1) Trifluralin. Continuous culture studies demonstrated that mixed ruminal bacterial suspensions and characterized pure cultures (Lachnospira multiparus and Bacteroides ruminicola subsp brevis) degrade the herbicide, trifluralin. Incubation experiments showed that only negligible quantities (less than 0.03%) of ^{14}C side-chain-labeled trifluralin was converted to $^{14}\text{CO}_2$. Both ^{14}C side-chain and ring-labeled trifluralin studies indicated that these anaerobes convert trifluralin primarily to two reductive metabolites, N,N-di-n-propyl-3-nitro-5-trifluoromethyl-o-phenylene-diamine and N,N-di-n-propyl- α , α , α trifluorotoluene-3,4,5-triamine. Several other metabolites that appear to be a monopropyl monoamine derivative and other dealkylation products are isolated and being characterized.

(2) Triazines. Extensive studies have demonstrated that ruminal microorganisms do not metabolize the triazine herbicides, propazine, atrazine, and simazine. In the in vitro studies, ^{14}C side-chain- and ring-labeled propazine, ^{14}C side-chain-labeled simazine and ^{14}C ring-labeled atrazine were incubated with: (1) ruminal digesta samples from animals on a high roughage and/or high concentrate rations in the presence or absence of daily feedings of propazine; (2) concentrated mixed ruminal bacterial

populations; (3) ruminal ciliated protozoal species, and (4) eleven characterized ruminal bacterial cultures grown for prolonged incubation periods with cold propazine.

The in vitro studies indicated that the triazines are not readily degraded, if at all, by rumen microbial sources under rigid in vitro anaerobic conditions. Evidence for this was that no $^{14}\text{CO}_2$ was produced from the ^{14}C ring- or side-chain-labeled triazines, and only traces of ^{14}C possible conversion products could be detected by paper, thin-layer, and ion-exchange chromatographic techniques.

These microbial sources showed no growth inhibition or endogenous gaseous and volatile fatty acid production when exposed to the triazines up to a concentration of 0.04% (w/v).

In in vitro experiments, propazine was fed to sheep to determine if the rumen microflora and fauna could utilize propazine by adaptation. In these experiments, rumen bacterial and ciliated protozoal populations and rumen volatile fatty acid concentrations were determined on sheep fed propazine at weekly levels of 0, 5, 10, 20 and 40 mg./kg. body weight per day. The data obtained suggested that propazine does not influence the rumen bacterial and ciliated protozoal populations, nor the concentrations of VFA at the levels of propazine tested.

In summary, the ruminant's body tissues appear to metabolically handle propazine unaltered by ruminal microorganisms. (03 99 008)

b. Antibiotics. The growth response of 17 characterized anaerobic bacterial strains were studied on different maintenance media containing 15 different antibiotics at levels of 5-10 μg and 14-30 μg . All the strains showed some growth suppression with bacitracin, chlorotetracycline, chloramphenicol, erythromycin, kanamycin, neomycin, novobiocin, aleandomycin, oxytetracycline, penicillin G, polymyxin B, streptomycin, terramycin, tylosin, and vancomycin. Resistant cells were observed in all cultures studied with streptomycin, kanamycin, neomycin, and polymyxin B. (03 99 004)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Beef Cattle

Rumsey, T. S., Corley, C., Putnam, P. A., Davis, R. E., and Argauer, R. J. 1966. DDT residue distribution in beef cattle. J. Animal Sci. 25:909. (Abst.)

Dairy Cattle

Beck, E. W., Johnson, J. C., Woodham, D. W., Leuck, D. B., Dowsey, L. H., Robbins, J. E., and Bowman, M. C. 1966. Residues of endosulfan in meat and milk of cattle fed treated forages. J. of Econ. Ent. 59:1444-50.

- Braund, D. G., Brown, L. D., Leeling, N. C., Zabik, M. J., and Huber, J. T. 1967. Storage, excretion and placental transfer of dieldrin by dairy heifers contaminated during three stages of gestation. J. Dairy Sci. 50:991. (Abst.)
- Fries, G. F., Flatt, W. P., and Moore, L. A. 1967. Body fat losses and excretion of DDT and its metabolites into milk. J. Dairy Sci. 50:991. (Abst.)
- King, R. L., Weissshoar, A., Hemken, R. W., Lester, J. W., and Heinle, E. 1967. Intake and retention of heptachlor epoxide by dairy animals during nonlactating periods. J. Dairy Sci. 50:991. (Abst.)

Broadly Based

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- Aschbacher, P. W., and Feil, V. J. 1967. Urinary metabolites of 3,5-diiodosalicylic acid in the bovine and rat. Am. Dairy Sci. Assoc. Abst., 62nd Meeting.
- Bakke, J. E., and Robbins, J. D. 1967. Metabolism of atrazine and simazine by the rat. Am. Chem. Soc. 153rd Meeting, Abst. No. 49A.
- Bakke, J. E., Robbins, J. D., and Feil, F. J. 1967. Metabolism of 2-chloro-4,6-bis(isopropylamino)-s-triazine (prometone) in the rat. Balance study and urinary metabolite separation. J. Agr. and Food Chem. 15:628-631.
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- Robbins, J. D., and Bakke, J. E. 1967. Sheep and goat metabolism unit for the collection of excreta and expired C¹⁴O₂. J. Animal Sci. 26:424-429.
- Williams, P. P. 1967. ¹⁴CO₂ trapping assembly for monitoring anaerobic microbial sources. Appl. Microbiol. 15:681-682.
- Williams, P. P. 1967. Trifluralin degradation of Lachnospira multiparus and Bacteroides ruminicola subsp. brevis. Bacteriol. Proc. p. 8.

AREA NO. 702. PROTECT ANIMAL PRODUCTS FROM HARMFUL
MICROORGANISMS AND TOXINS

Problem. Agriculture has the responsibility to ensure the production of foods safe to eat and of nonfood products safe to use. The United States enjoys a reputation for food supplies that are, micro-biologically speaking, among the safest in the world. Nevertheless, expanded reporting on communicable diseases indicates that Salmonellosis in humans is a significant problem. The majority of foodborne outbreaks of Salmonellosis involve food products of animal origin. To reduce the risk to man from these and other harmful microorganisms and toxins, agriculture must ensure that its products are safe to eat or use.

USDA AND COOPERATIVE PROGRAM

A. Dairy

The dairy research in this area includes a study in depth of the biology and physiology of aflatoxin toxicity and a contract with the University of Wisconsin to study the effects of varying environmental conditions on the development of mycotoxins on forages. Initial efforts on the latter have been directed toward studies of A. flavus on alfalfa.

B. Poultry

The limited activity of poultry research in this area is confined to cooperative work with ADP on fumigation of eggs with formaldehyde.

The total Federal effort under Area No. 702 is 1.2 SMY intramural and 0.2 SMY extramural, all on dairy.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State stations in this area totals 2.1 SMY.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Dairy

1. Evaluating the hazard of mycotoxin in cattle feeds

a. The physiological effects of aflatoxin on young dairy calves.
A program has been initiated at Beltsville to study in depth the biology and physiology of aflatoxin toxicity. The effects on the whole animal, specific organs and at the cellular level are being observed. Effects at the cellular level are considered of special importance since the material

is a known carcinogen. The cooperative efforts of three government agencies have been combined in order to carry out the project.

The purpose of the current work is to define the aflatoxin dose relationships, the tissue and cellular effects of feeding aflatoxin to young dairy calves. Preliminary evaluation of results from feeding six dose levels, 0.001 mg. to 0.080 mg. aflatoxin B₁/kg. body weight/day, indicate that aflatoxin or its fungal substrate reduces feed intake in dairy calves when incorporated into the grain ration. Clinical biochemical data indicated that the electrophoretically determined albumin/globulin ratio was lowered significantly by aflatoxin feeding but total serum protein levels were unchanged within the six-week feeding period employed. Serum alkaline phosphatase values were increased significantly at aflatoxin dose levels of 0.020 mg. aflatoxin B₁/kg. body weight/day or greater. Some of the experimental animals exhibited elevated alkaline phosphatase values as early as one week after the initial aflatoxin dose. Definite color changes in the livers and an increase in adrenal sizes were noted upon examination of the aflatoxin treated calves at postmortem. Pathological examination by light microscopy revealed early proliferative changes and fatty infiltration of the liver cells of the aflatoxin fed calves. At the cellular level, one of the most obvious changes produced by aflatoxin feeding was a loss of ribosomes from the endoplasmic reticulum. Other work has suggested that the inhibition of m/RNA production in the nucleus is responsible for the loss of ribosomes from the cytoplasmic endoplasmic reticulum. These results would support the current theory of the inhibition of protein synthesis by aflatoxin. Our work to date would also support the fact that aflatoxin induced changes at the clinical biochemical, tissue and cellular levels are similar to those found in other species. A more intensive examination of aflatoxin induced changes at the biological level is now in progress with both dairy calves and small laboratory animals. (03 31 042)

b. The natural occurrence of mycotoxin in forages. A two year contract has been awarded at the University of Wisconsin to study the effects of varying environmental conditions on the development of mycotoxins on forages. Initial efforts have been directed toward studies of A. flavus on alfalfa. A method has been developed for aflatoxin assay that provides for the removal of interfering pigments with a lead acetate precipitation. The clear extract can be assayed with thin layer chromatography. Preliminary results indicate that under moist conditions A. flavus will grow readily and compete well with naturally occurring fungi on alfalfa. However, neither of two field samples of alfalfa contained significant A. flavus numbers. At this point, most of the A. flavus isolates from Wisconsin have not been capable of producing aflatoxin B₁. (03 31 020)

B. Poultry

1. Fumigation of eggs with formaldehyde. In cooperative work with ADPRD, the effects of several variables on the amount of formaldehyde

deposited, or remaining on the shell, shell membranes and albumin of eggs were investigated.

Formaldehyde was rapidly dissipated from the shell within 30 minutes after fumigation, the level falling from an average of 140 ppm by weight immediately after fumigation by standard procedures to about 45 ppm at 30 minutes. However, detectable amounts (approximately 4 ppm) were found after three weeks of storage.

The amount of the chemical retained on the shells of brown eggs was significantly greater than that found on white eggs receiving the same treatment. Washing the eggs after fumigation reduced the formaldehyde concentration on the shells, but had a greater effect on brown eggs than on white eggs.

The amount of formaldehyde which remained on the shell was significantly reduced if relative humidity was raised to 100% during fumigation, but storage of eggs at 10° C. (50° F.) prior to fumigation increased the concentration of formaldehyde due to condensation of moisture on the shell surface when the eggs were placed in the fumigation cabinet.

Concentrations of formaldehyde in the shell membranes of brown eggs were higher than those of white eggs (37 ppm vs. 17 ppm) and levels in the albumin of both egg types were at or below 1 ppm which was the limit of detectable accuracy of the method employed.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Dairy

Lynch, G. P., Courington, D. P., Todd, G. C., Shalkop, W. T., and Moore, L. A. 1967. Aflatoxin dose relationships in young dairy calves. Mycotoxin Seminar, USDA, Washington, D. C. June 8-9, 1967. (In press)

AREA NO. 901. ALLEVIATE SOIL, WATER AND AIR POLLUTION

Problem. Soil, water and air are being polluted with a variety of substances, both inorganic and organic. Except for certain substances, it is not yet possible to assess the severity and extent of this pollution. The trend toward concentrated livestock and poultry production operations and spreading urban developments make pollution from animal sources an increasing problem. Soil, water and air become contaminated with microorganisms, dust and odors from livestock and poultry wastes. Methods are needed for collecting, storing, moving and disposing of animal wastes that preclude risks to human health and alleviate the odors, dust and noise from livestock operations.

USDA AND COOPERATIVE PROGRAM

Poultry

A cooperative agreement has been initiated with Cornell University to study various aspects of the poultry waste problem. The Animal Husbandry Research Division is cooperating in research directed towards the identification of the odor producing organisms in poultry manure, and in developing methods for destroying these organisms.

Simultaneously, the Agricultural Engineering Research Division is cooperating with Cornell University in an investigation of the energy required to remove moisture from animal manures by thermal means with emphasis on odor control and handling ease.

The total AH Federal effort devoted to this area is 0.5 SMY extramural.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State stations in this area totals 3.0 SMY.

PROGRESS -- USDA AND COOPERATIVE PROGRAM

None

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None

CRIS Unit Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 29		Poultry *			
03 29 001	701	Feed as an unavoidable source of pesticide contamination in poultry meat and eggs.	Columbus, Ohio	No	
03 29 002	313a	Evaluation of breeding systems for chickens.	Lafayette, Ind.	Yes	313a C-5,6
03 29 003	313a	Development and evaluation of breeding techniques in chickens.	Athens, Ga.	Yes	313a C-1,5
03 29 004	313a	Avian reproduction under sub-circadian periodicities.	Beltsville, Md.	Yes	311 C-4
03 29 005	311	Genetic aspects of the ability of chickens to utilize amino acids.	Beltsville, Md.	Yes	311 C-5
03 29 006	313a	Physiological and pleiotropically controlled traits as they apply to the performance of the fowl.	Beltsville, Md.	No	
03 29 007	313a	Biochemical basis for genetic differences in growth rate of poultry.	Beltsville, Md.	Yes	311 C-6
03 29 008	313a	Selection for hatchability of turkey eggs at different altitudes.	Lafayette, Ind.	No	
03 29 009	313a	Effect of interspecies blood injections on heritable traits of the domestic fowl.	Lafayette, Ind.	No	
03 29 010	313a	Importance of cage density.	Athens, Ga.	Yes	313a C-2
03 29 011	313a	Cytologenetetic studies with avian species.	Beltsville, Md.	Yes	313a C-3
03 29 012	313a	Selection, growth and feed conversion in poultry.	Beltsville, Md.	No	
03 29 013	313a	Genetic aspects of selection plateaus in Japanese quail.	Beltsville, Md.	Yes	313a C-4
03 29 014	312	Dietary requirements of chickens during hot weather.	Glendale, Ariz.	No	
03 29 015	409	Levels of toxic cottonseed constituents in diets that affect performance of poultry.	Glendale, Ariz.	Yes	311 C-3b
03 29 016	701	Malathion residues in poultry meat and eggs.	Ames, Iowa	No	
03 29 017	311	Energy and fatty acids in poultry nutrition.	Beltsville, Md.	Yes	311 C-1a, 2c
03 29 018	701	DDT residues in egg and body tissues of hens.	Athens, Ga.	Yes	701 C-2

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Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 29 019	310	Parthenogenesis in avian eggs.	Beltsville, Md.	Yes	310 C-2
03 29 020	313a	The homograft reaction and immunological tolerance in birds.	Beltsville, Md.	Yes	310 C-3
03 29 021	310	Pituitary-ovarian relationships controlling egg production in Coturnix quail.	Beltsville, Md.	Yes	310 C-1
03 29 022	409	Control of eggshell pigmentation in Japanese quail.	Beltsville, Md.	Yes	409 C-1
03 29 023	211	Production and maintenance of chickens susceptible but free of lymphomatosis.	East Lansing, Michigan	No	
03 29 024	211	Immunity of chickens to avian tumor viruses.	East Lansing, Michigan	No	
03 29 025	211	Epizootiology of avian lymphomatosis and related neoplasms.	East Lansing, Michigan	Yes	211 C-2
03 29 026	211	Genetic variability remaining in highly inbred chickens.	East Lansing, Michigan	Yes	211 C-1
03 29 027	211	Genetic resistance and susceptibility to virus induced neoplasms of chickens.	East Lansing, Michigan	Yes	211 C-2
03 29 028	211	Genetic resistance and susceptibility to Marek's disease in chickens.	Ithaca, N. Y.	Yes	211 C-4c
03 29 029	211	Pathology and etiology of skin leukosis (Marek's disease), arthropods role and decontamination of houses.	Fayetteville, Ark.	Yes	211 C-4a
03 29 030	211	Detection and identification of etiological agent of Marek's disease.	Davis, Calif.	Yes	211 C-4b
03 29 031	211	Development of assay systems for causative agent of Marek's disease.	Storrs, Conn.	Yes	211 C-4d
03 29 032	211	Determine effect of GA (Marek's disease) isolate on various lines and crosses and role of coccidiosis in cause and transmission.	Athens, Ga.	Yes	211 C-4e
03 29 033	211	Develop bioassay method and characterization of JM virus.	Amherst, Mass.	No	
03 29 034	211	Host-cell oncogenic virus relationship.	East Lansing, Michigan	No	
03 29 035	211	Antigenic and host range characterization of the avian tumor viruses.	East Lansing, Michigan	Yes	211 C-2

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Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 29 036	211	Role of lymphoid organs in pathogenesis of neoplasms of avian leukosis complex.	East Lansing, Michigan	Yes	211 C-2
03 29 037 1	211	Skeletal and muscular systems of domesticated and laboratory birds.	East Lansing, Michigan	Yes	211 E
2	310	Skeletal and muscular systems of domesticated and laboratory birds.	East Lansing, Michigan	Yes	211 E
3	311	Skeletal and muscular systems of domesticated and laboratory birds.	East Lansing, Michigan	Yes	211 E
4	312	Skeletal and muscular systems of domesticated and laboratory birds.	East Lansing, Michigan	Yes	211 E
5	313a	Skeletal and muscular systems of domesticated and laboratory birds.	East Lansing, Michigan	Yes	211 E
6	313b	Skeletal and muscular systems of domesticated and laboratory birds.	East Lansing, Michigan	Yes	211 E
7	409	Skeletal and muscular systems of domesticated and laboratory birds.	East Lansing, Michigan	Yes	211 E
03 29 038	211	Maintenance of genetic lines of chickens free of leukosis, infectious and parasitic diseases.	East Lansing, Michigan	No	
03 29 039	211	Develop and maintain lymphomatosis resistance and susceptible inbred lines of chickens.	East Lansing, Michigan	Yes	211 C-1
03 29 040	211	Incidence of avian leukosis in Israel and improved diagnostic tests for AL.	Ness-Ziona, Israel	No	
03 29 041	211	Management, disease and environmental factors affecting airsacculitis and broiler condemnations.	State College, Miss.	No	
03 29 042	211	Genetic resistance and susceptibility of chickens to Newcastle virus.	Athens, Ga.	Yes	211 D
03 29 043	211	Response of chickens to hormonal and environmental stimuli.	Athens, Ga.	Yes	312 C-1,2,3
03 29 044	211	Management factors influencing airsacculitis and condemnation in broilers.	State College, Miss.	Yes	312 C-4,5,6
03 29 045	310	Mechanisms controlling oviposition and ovulation in birds.	Beltsville, Md.	Yes	310 C-1
03 29 046	310	Ovarian feedback hormones (estrogens, progestogens and possibly androgens) in the avian ovulation cycle.	Beltsville, Md.	No	
03 29 047	310	Bacteriological problems in artificial insemination of hens.	Rehovoth, Israel	No	

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Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 29 048	310	Selection and artificial insemination with turkey semen for increasing fertility of chickens.	Rehovoth, Israel	No	
03 29 049	311	Factors which affect variability in weight gain and feed efficiency in chickens.	Beltsville, Md.	No	
03 29 050	311	Evaluation of feedstuffs available in India for protein quality and energy value.	Ludhiana, India	Yes	311 C-3a
03 29 051	312	Influence of temperature stress on selection in <i>Tribolium</i> .	Madrid, Spain	No	
03 29 052	313a	Collection and evaluation of native fowl germ plasm.	Udaipur, India	No	
03 29 053	701	Influence of pesticidal chlorinated hydrocarbons upon mechanism in poultry.	Zagreb, Yugoslavia	No	
03 29 054	313a	Collection and evaluation of native fowl germ plasm.	Ludhiana, India	No	
03 29 055	313a	Improving and evaluating Fayoumi and Dandarawi fowl.	Dokki, Giza, Egypt (UAR)	No	
03 29 056	409	Calcium and phosphorus metabolism in the chicken and factors influencing eggshell quality.	Rehovoth, Israel	Yes	311 C-2b
03 29 057	409	Influence of growth hormones on fat metabolism in adult hens.	Warsaw, Poland	No	
03 29 058	211	Spread of lymphomatosis by contaminated litter.	Vineland, N. J.	No	
03 29 059	211	Control of hatchery-disseminated diseases.	Beltsville, Md.	Yes	313b C-1
03 29 060	313a	Evaluation of poultry stocks through random sample tests.	Beltsville, Md.	Yes	313b C-2
03 29 061	211	Blood group systems in highly inbred lines.	Auburn, Ala.	No	
03 29 062	211	Mosquitoes, mites and poultry litter as reservoirs of Marek's disease and age effect on susceptibility to Marek's disease.	Athens, Ga.	No	
03 29 063	211	Refinement and evaluation of <u>in vitro</u> assay systems for Marek's disease agent.	Storrs, Conn.	No	
03 29 064	211	Genetics of avian cells in culture.	Beltsville, Md.	No	
03 29 065	310	Function of linoleic acid in hatchability of the chicken egg.	Beltsville, Md.	No	

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Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 29 066	310	Role of reproductive hormones in the linoleic acid deficient laying hen.	Beltsville, Md.	No	
03 29 067	311	Dietary amino acid balance for optimum growth and feed conversion of poultry.	Beltsville, Md.	No	
03 29 068	311	Utilization and function of vitamin A in the nutrition of poultry.	Rehovoth, Israel	Yes	311 C-2a
03 29 069	901	Poultry waste disposal and associated odor control.	Ithaca, N. Y.	No	
03 29 070	211	Antigenic and host range characterizations of the avian tumor viruses.	East Lansing, Michigan	No	
03 29 071	211	Determine whether Marek's disease tumors are transplants or of host origin.	East Lansing, Michigan	No	
03 29 072	211	Development of serological methods and reagents for the study of Marek's disease (MD).	East Lansing, Michigan	No	
03 29 073	211	The auto-immune pathogenesis of Marek's disease.	East Lansing, Michigan	No	
03 29 074	211	Etiological studies of Marek's disease.	East Lansing, Michigan	No	
03 29 075	211	Ultrastructural studies of Marek's disease (MD) tumors.	East Lansing, Michigan	Yes	211 C-3
03 29 076	211	Studies on chemical bursectomy as a means of controlling lymphoid leukosis.	East Lansing, Michigan	No	
03 29 077	211	Cytology of visceral lesions of Marek's disease (MD) and lymphoid leukosis (LL).	East Lansing, Michigan	Yes	211 C-3
03 29 078	211	Studies on the pathogenesis of Marek's disease (MD) and lymphoid leukosis (LL).	East Lansing, Michigan	No	
03 29 079	211	Mechanisms for the natural transmission of Marek's disease.	East Lansing, Michigan	Yes	211 C-3
03 29 080	211	Relationship of Marek's agent to disease in commercial and experimental flocks.	East Lansing, Michigan	No	
03 29 081	211	Development of methods for the assay of Marek's disease agent in cell culture.	East Lansing, Michigan	Yes	211 C-3
03 29 082	211	Investigation of genetic variation in control of antibody production in response to antigen stimulation.	East Lansing, Michigan	No	

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				Summary of Progress (Yes-No)	Area & Subheading
03 29 083	211	Skin grafting in the RPRL inbreds to develop isohistogenic sublines.	East Lansing, Michigan	No	
03 29 084	211	Genetics of Marek's disease.	East Lansing, Michigan	No	
03 29 085	211	The effect of nutritional factors on broiler losses caused by disease.	State College, Miss.	No	
03 29 086	312	The interrelation of nutritional and environmental factors in broiler losses.	State College, Miss.	No	
03 29 087	312	Temperature and broiler losses.	State College, Miss.	No	
03 29 088	312	Temperature-density interaction for broilers.	State College, Miss.	No	
03 29 089	312	Physiological changes associated with hypothermia and hyperthermia of broilers.	State College, Miss.	No	
03 29 090	211	Blood changes related to broiler losses.	State College, Miss.	No	
03 29 091	312	Thermodynamic analyses of a broiler.	State College, Miss.	No	

* Some CRIS Units were developed too late to be referenced, but results are reported.

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Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 30		Beef Cattle*			
03 30 001	312	Selection of cattle adapted to beef production in the Southeastern United States.	Brooksville, Fla.	Yes	310 A-1
03 30 002 1	409	Selection for changes in leanness and adaptability in beef cattle in the Gulf Coast area.	Jeanerette, La.	No	
2	312	Selection for changes in leanness and adaptability in beef cattle in the Gulf Coast area.	Jeanerette, La.	No	
03 30 003	313a	Heterosis from crosses among British breeds of beef cattle.	Blacksburg, Va.	Yes	313a A-1
03 30 004	409	Improve palatability of beef and beef cattle production.	Knoxville, Tenn.	No	
03 30 005	313a	Selection, inbreeding and crossing of inbred lines within the Hereford breed.	Ft. Collins, Colo.	Yes	313a A-1 313b A-1
03 30 006	313a	Selection for productivity and carcass characters in beef cattle.	El Reno, Okla.	Yes	310 A-4 313a A-1,6
03 30 007	313a	Genetic and environmental interactions for performance and carcass traits in beef cattle.	Raleigh, N. C.	Yes	313a A-2
03 30 008	310	Increasing reproductive efficiency in range beef cattle.	Miles City, Mont.	Yes	310 A-1,3, 4
03 30 009	313a	Biochemical and cytological investigations of inherited dwarfism in beef cattle.	Gainesville, Fla.	No	
03 30 010	313a	Interactions between genotype and environment in selection for economic traits in Hereford cattle.	Reno, Nev.	Yes	313a A-3
03 30 011	313a	Heterotic effects in crosses of the Angus, Hereford and Shorthorn cattle.	Davis, Calif.	Yes	409 A-3 313a A-1
03 30 012 1	313a	Responses to selection and genetic-environmental interaction in genetically similar Hereford cattle at two locations.	Miles City, Mont.	Yes	313a A-5
2	312	Responses to selection and genetic-environmental interaction in genetically similar Hereford cattle at two locations.	Brooksville, Fla.	No	
03 30 013	310	Increasing the reproductive efficiency of beef cattle.	El Reno, Okla.	No	

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Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 30 014	313a	Genetic and environmental influences on traits of economic value in beef cattle.	Madison, Wisc.	Yes	310 A-1
03 30 015	313a	Basic population aspects of qualitative and cytological characters of beef cattle.	College Station, Tex.	Yes	311 A-4 313a A-1, 7,8
03 30 016 1	701	Metabolism of pesticides by beef cattle.	Tifton, Ga.	Yes	213 A
2	701	Metabolism of pesticides by beef cattle.	Beltsville, Md.	Yes	213 A
3	701	Metabolism of pesticides by beef cattle.	Front Royal, Va.	Yes	701 A
03 30 017	312	Breeding and selection of beef cattle for the Southwest.	Tucson, Ariz.	Yes	313a A-8
03 30 018	313a	Progeny testing, selection and systems of breeding for more efficient beef cattle for Georgia.	Tifton, Ga.	Yes	313a A-1
03 30 019	313a	Breeding superior beef cattle for Virginia.	Front Royal, Va.	Yes	310 A-1 313a A-3
03 30 020	313a	Inbreeding and selection in the improvement of performance of beef cattle.	Brookings, S. D.	Yes	409 A-3 313a A-1,4
03 30 021	313a	Improving beef cattle through breeding methods.	Ames, Iowa	No	
03 30 022	313a	Selection for productive efficiency and carcass merit and heterosis in beef cattle.	Crawford, Nebr.	Yes	311 A-5 313a A-1, 2,3,5
03 30 023	409	Heritability of various components of serum lipids and the composition and distribution of fat in beef cattle.	Ft. Collins, Colo.	Yes	409 A-4,5
03 30 024	313a	Genetics of certain protein components in milk from beef cows.	Bozeman, Mont.	Yes	313a A-1
03 30 025	313a	Breeding crossing in beef cattle for increased production.	Miles City, Mont.	Yes	313a A-7
03 30 026	310	Nutrition and management of the reproducing beef cow and the young calf.	Beltsville, Md.	Yes	310 A-1 312 A
03 30 027 1	311	Nutritive value of feeds and forages to beef cattle as influenced by chemical and ration composition or form.	Beltsville, Md.	Yes	311 A-2a 313b A-2

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				Summary of Progress (Yes-No)	Area & Subheading
03 30 027 2	311	Nutritive value of feeds and forages to beef cattle as influenced by chemical and ration composition or form.	El Reno, Okla.	Yes	311 A-2b
03 30 028	211	Cause and prevention of urinary calculi in fattening cattle and sheep.	College Station, Tex.	Yes	211 A-1
03 30 029	310	Influence of pastures and forages on reproductive performance of beef cattle in the Gulf Coast area.	Jeanerette, La.	No	
03 30 030	311	Nutrition and management in the growth of beef cattle.	Newell, S. D.	No	
03 30 031	310	Growth, development, and reproductive performance of beef heifers and cows under different winter feeding treatments.	El Reno, Okla.	Yes	310 A-1
03 30 032 1	311	Nitrogen metabolism and requirements in beef cattle.	Beltsville, Md.	Yes	213 A 311 A-1a, 2a
2	311	Nitrogen metabolism and requirements in beef cattle.	Brooksville, Fla.	No	
3	311	Nitrogen metabolism and requirements in beef cattle.	Front Royal, Va.	Yes	313b A-2
4	311	Nitrogen metabolism and requirements in beef cattle.	El Reno, Okla.	No	
03 30 033	311	Utilization of corn, milo, barley and wheat in rations of beef cattle.	Davis, Calif.	Yes	311 A-2b
03 30 034	311	Ruminal and postruminal digestion of starch by beef cattle.	Lexington, Ky.	Yes	311 A-1a
03 30 035	311	Supplements to control feed intake of beef cattle.	Gainesville, Fla.	Yes	311 A-3
03 30 036	310	Endocrine function and energy retention of the postpartum beef female as influenced by pre-partum energy intake.	Lincoln, Nebr.	Yes	313b A-2
03 30 037	311	Forages for beef production in the Coastal Plain region.	Tifton, Ga.	No	
03 30 038	701	Pesticide residues ingested by finishing and reproducing beef cattle.	Front Royal, Va.	No	
03 30 039 1	213	Organic phosphate systemic insecticides and embryonic survival and development in the bovine.	Miles City, Mont.	No	

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				Summary of Progress (Yes-No)	Area & Subheading
03 30 039 2	213	Organic phosphate systemic insecticides and embryonic survival and development in the bovine.	Crawford, Nebr.	No	
3	213	Organic phosphate systemic insecticides and embryonic survival and development in the bovine.	Miles City, Mont.	No	
4	213	Organic phosphate systemic insecticides and embryonic survival and development in the bovine.	Crawford, Nebr.	Yes	213 A
5	213	Organic phosphate systemic insecticides and embryonic survival and development in the bovine.	Beltsville, Md.	No	
03 30 040	313b	Use of supplemental spring pasture and range management for sustained beef cattle production in the Northern Great Plains.	Miles City, Mont.	Yes	313b A-2
03 30 041	313b	Nutrition and breeding management of beef cattle.	El Reno, Okla.	No	
03 30 042	313b	Livestock and timber production on native range and on intensively managed pastures.	Tifton, Ga.	No	
03 30 043	311	Compensatory growth in mammals and its application to intensive beef production.	Rehovoth, Israel	No	
03 30 044	311	Trace element contents in forage crops in relation to the stage of development of the plants, the methods of gathering and storage.	Poznan, Poland	Yes	311 A-6
03 30 045	311	The nutritional value of fish silage produced by yeast fermentation for animal feeding.	Montevideo, Uruguay	No	
03 30 046	311	Ruminal microorganisms and their contribution to beef cattle nutrition.	Beltsville, Md.	Yes	311 A-1b
03 30 047 1	313a	Genetic improvement of beef cattle productivity and carcass value in the West.	Ft. Collins, Colo.	No	
2	313a	Genetic improvement of beef cattle productivity and carcass value in the North Central area.	Lincoln, Nebr.	No	
3	313a	Genetic improvement of beef cattle productivity and carcass value in the South.	Knoxville, Tenn.	No	

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				Summary of Progress (Yes-No)	Area & Subheading
03 30 048	313a	Development and evaluation of closed lines of Hereford beef cattle.	Miles City, Mont.	No	
03 30 049	311	Reactions in the guinea pig liver microsomes during protein bio- synthesis <u>in vitro</u> .	Warsaw, Poland	No	

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Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 31		Dairy Cattle*			
03 31 001 1	313a	Genetics of feed utilization among sires and environments	Beltsville, Md.	Yes	313a B-3a, 4d
2	313a	Genetics of feed utilization among sires and environments.	Logan, Utah	Yes	313a B-3c
3	313a	Genetics of feed utilization among sires and environments.	Lewisburg, Tenn.	Yes	313a B-3b
03 31 002	409	Genetics of milk composition.	Beltsville, Md.	Yes	409 B-1a,b
03 31 003	313a	Comparison tests in cattle blood typing.	Beltsville, Md.	Yes	313a B-4a
03 31 004	310	The importance of immunogenetic factors in problems of lowered fertility in cattle.	Beltsville, Md.	No	
03 31 005	311	Raising meat animals from dairy and beef calves.	Madison, Wisc.	Yes	311 B-5b
03 31 006	313a	Inbreeding, outbreeding and inter-line crossing to improve performance in dairy cattle.	Madison, Wisc.	Yes	313a B-2f,j
03 31 007	313a	General and specific combining ability in dairy cattle genetics.	Columbus, Ohio	Yes	313a B-2i
03 31 008 1	313a	Interbreed matings as a method of improving dairy cattle.	Beltsville, Md.	No	
2	313a	Interbreed matings as a method of improving dairy cattle.	Lafayette, Ind.	Yes	313a B-2g
3	313a	Interbreed matings as a method of improving dairy cattle.	Urbana, Ill.	Yes	313a B-2d, 3d,e,g
03 31 009	313a	Parental relationship influences on production traits.	Beltsville, Md.	Yes	313a B-2b,e
03 31 010	313a	Using progeny tested sires and their sons for improving dairy cattle.	Beltsville, Md.	Yes	313a B-2a
03 31 011	313a	Methods of using sires in AI.	St. Paul, Minn.	Yes	313a B-2h, 3f
03 31 012	409	Selection for milk production vs. high protein percent.	Cortland, N. Y.	No	
03 31 013	313b	Mechanical equipment to improve dairy management methods.	Beltsville, Md.	No	
03 31 014	701	Evaluation of mechanical sanitation as a means of reducing fly populations on dairy farmstead.	Baton Rouge, La.	Yes	701 B-2b
03 31 015 1	312	Anatomical and physiological relationships to adaptability of cattle.	Beltsville, Md.	Yes	312 B-2

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Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 31 015 2	312	Anatomical and physiological relationships to adaptability of cattle.	Baton Rouge, La.	No	
03 31 016 1	312	Breeding for adaptability to hot and humid climates.	Tifton, Ga.	No	
2	312	Breeding for adaptability to hot and humid climates.	Jeanerette, La.	Yes	312 B-1
03 31 017 1	312	Management practices for cattle in hot and humid areas.	Tifton, Ga.	No	
2	312	Management practices for cattle in hot and humid areas.	Jeanerette, La.	No	
03 31 018	311	Intake of hay crop silage by dairy heifers.	Beltsville, Md.	Yes	311 B-3e
03 31 019	311	Utilization of the carotene from corn silage by dairy calves as affected by nitrate content.	Beltsville, Md.	Yes	311 B-3a,b
03 31 020	702	Factors affecting the development of fungal toxins in forages.	Madison, Wisc.	Yes	702 A-1b
03 31 021	311	Nonprotein nitrogen utilization in the ruminant.	Ft. Valley, Ga.	Yes	311 B-3d
03 31 022	311	Biochemistry and rumen microbiology of feeds and forages and their nutritive value.	Beltsville, Md.	Yes	311 B-2a,b, c,d,e,f
03 31 023	701	Residues in milk from cows fed insecticide contaminated forage.	Tifton, Ga.	Yes	701 B-1b,e
03 31 024	311	Vitamin B ₁₂ -protein complexes from microorganisms and animal liver.	Poznan, Poland	Yes	311 B-6c
03 31 025	311	Calorimetry methods and nutritional evaluation of feeds for dairy cattle.	Beltsville, Md.	Yes	311 B-1a,b, c,d,e,f,g
03 31 026	311	Protein compounds of vitamin B ₁₂ and its analogs.	Poznan, Poland	No	
03 31 027	311	Liberal concentrate feeding to dairy cattle.	Ithaca, N. Y.	No	
03 31 028	701	Absorption and excretion of heptachlor epoxide by dairy cattle.	College Park, Md.	Yes	701 B-1c
03 31 029	701	Insecticide residues in tissues and milk of dairy cows.	Beltsville, Md.	Yes	701 B-1d
03 31 030	311	Management, preservation and utilization of grassland crops for dairy cattle.	Beltsville, Md.	Yes	311 B-3c, 4c,e,f,g,h, i,j

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				Summary of Progress (Yes-No)	Area & Subheading
03 31 031	311	Grazing pasture forage compared to harvesting as silage for dairy cattle.	Lewisburg, Tenn.	Yes	311 B-4a
03 31 032	311	Date of cutting and dry matter content influences on value of forages fed to cattle.	Logan, Utah	Yes	311 B-4b
03 31 033	311	Concentrate supplementation responses of dairy cows on pasture and drylot rations.	Logan, Utah	No	
03 31 034	311	Variety, selection, production methods and feeding value of corn silage.	College Park, Md.	Yes	311 B-4d
03 31 035	310	Azasteroid analogs of male and female sex hormones.	Chandigarh, India	No	
03 31 036	310	Augmentation of lactation by hypothalamic stimulation.	Jerusalem, Israel	No	
03 31 037	310	Physiological basis for lowered fertility in cattle.	Madison, Wisc.	Yes	310 B-4a,b, c,d,e,f,g
03 31 038	310	Effect of pH and ionic composition on vasopressin control of water transport through animal membranes.	Jerusalem, Israel	Yes	310 F-5
03 31 039	313a	Estimating breeding value of production traits in dairy cows and sires.	Beltsville, Md.	Yes	313a B-1b,c e,j
03 31 040	313b	Dairy herd improvement through recordkeeping and analysis of herdmates.	Beltsville, Md.	Yes	313a B-1a, f,g,h,i 313b B-3
03 31 041	313a	Dairy cattle population genetics.	Beltsville, Md.	Yes	313a B-1d, 2c
03 31 042	702	Effects of mycotoxins when fed to dairy cattle.	Beltsville, Md.	Yes	702 A-1a
03 31 043	313b	Identification of livestock.	Beltsville, Md.	No	
03 31 044	701	Mastitis and mammary gland defenses.	Beltsville, Md.	Yes	211 B-1,2
03 31 045	701	Development of nonchemical methods of dairy cattle pest control.	Beltsville, Md.	Yes	701 B-2b
03 31 046	311	Nutritional physiology of different breeds of Indian cattle.	Karnal, India	No	
03 31 047	311	Utilization of low grade forages by Indian cattle.	Chandigarh, Punjab, India	No	
03 31 048	310	Ovarian function and its experimental control in the water buffalo (Bos-bubalis)	Anand, Giyarat State, India	No	

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				Summary of Progress (Yes-No)	Area & Subheading
03 31 049	310	Comparative studies of "repeat-breeders" and normal cows and heifers.	Beit Dagan, Israel	Yes	310 B-5
03 31 050	311	Concentrate feeding and reproductive management to increase milk production of dairy cattle.	Beit Dagan, Israel	Yes	311 B-7
03 31 051	311	Detoxication of free ammonia in ruminants.	Zagreb, Yugoslavia	No	
03 31 052	311	Effects of composition and physical form of rations on growth and milk production of cattle	Zemun, Yugoslavia	No	
03 31 053	311	Influence of dietary fat on economy of utilization of energy of rations.	Beltsville, Md.	No	
03 31 054	311	Ruminal synthesis of vitamin B ₁₂ and its analogs in dairy cattle.	Beltsville, Md.	Yes	311 B-6a,b
03 31 055	310	Immunogenetic factors relating to calf livability with particular reference to the thymus.	Beltsville, Md.	Yes	313a B-2k
03 31 056	313a	Genetics and chemistry of blood groups and other polymorphisms in cattle.	Columbus, Ohio	Yes	313a B-4b, c,e
03 31 057	313a	Relationships of beef and dairy characters in milking Shorthorn cattle.	St. Paul, Minn.	Yes	311 B-5a 409 A-2
03 31 058	311	Genetics of feed utilization in feeding systems.	Beltsville, Md.	No	
03 31 059	311	Genetics of feed utilization in mating systems.	Beltsville, Md.	No	
03 31 060 1	310	Endocrine control of animal reproduction.	Beltsville, Md.	Yes	310 B-2a,b, c,d,e,B-3a, b,c,d,e,f
2	310	Endocrine control of animal reproduction.	Beltsville, Md.	Yes	" "
03 31 061	313b	Evaluation of testing, weighing, measuring and sampling devices for DHIA.	Beltsville, Md.	Yes	313b B-1,2
03 31 062	701	Effect of drugs, lignin derivatives and charcoal on storage and excretion of dieldrin by dairy cattle.	East Lansing, Michigan	No	
03 31 063	313a	Blood type characteristics of Yugoslavian cattle.	Ljublijana, Yugoslavia	No	
03 31 064	310	Separation of spermatozoa of different sizes.	Beltsville, Md.	No	

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				Summary of Progress (Yes-No)	Area & Subheading
03 31 065	311	Increasing the use of non-protein nitrogen in dairy cattle rations.	Beltsville, Md.	No	
03 31 066	701	Control of flies with larvicides added to rations and manure.	Beltsville, Md.	Yes	701 B-2a
03 31 067	701	Metabolism of diuron in ruminants.	Tuskegee, Ala.	No	
03 31 068	701	The accumulation and excretion of dieldrin in dairy heifers and cows.	East Lansing, Michigan	No	
03 31 069	701	The metabolic fate of an organic phosphate insecticide (GS-13005) when fed to dairy cattle.	Blacksburg, Va.	Yes	701 B-1a

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Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 32		Swine*			
03 32 001	313a	Selection for combining ability in crosses between Yorkshires and Montana No. 1 swine.	Miles City, Mont.	Yes	313a E-1i
03 32 002	409	Selection for high and low degrees of fatness in swine.	Beltsville, Md.	Yes	409 E-1 313a E-2f
03 32 003	313a	Selection for combining ability in crosses between two strains of swine.	Beltsville, Md.	Yes	313a E-1i
03 32 004	313a	Selection in purebred and crossbred foundation herds of swine.	Urbana, Ill.	No	
03 32 005	313a	Selection, inbreeding, and crossing for swine improvement.	St. Paul, Minn.	Yes	313a E-1e, f,2c
03 32 006	313a	Selection procedures within lines of swine for crossbreeding.	Lafayette, Ind.	Yes	313a E-2b,c
03 32 007	313a	Genetic polymorphisms in the body fluids of swine.	Beltsville, Md.	Yes	310 E-1a,b, c,d,e 313a E-1a, b,c
03 32 008	310	Synchronization of estrus in swine.	Beltsville, Md.	No	
03 32 009	310	Lipid, fatty acid, and free amino acid composition of ejaculated and epididymal boar semen.	Beltsville, Md.	No	
03 32 010	310	Nature of genetic variability in gene pools of swine.	Lincoln, Nebr.	Yes	310 E-1g,j
03 32 011	409	Selection for low backfat thickness in swine.	Columbia, Mo.	Yes	313a E-1g
03 32 012	313a	Genetic relationships between purebred and crossbred swine.	Ames, Iowa	No	
03 32 013	313a	Selection for maximum improvement in swine with a minimum of expenditures.	East Lansing, Michigan	No	
03 32 014	313b	Evaluation of new hog-rearing equipment.	Beltsville, Md.	No	
03 32 015	313b	Evaluation of management practices in swine production.	Beltsville, Md.	No	
03 32 016	701	Control of flies and other insects associated with swine production without insecticides.	Lafayette, Ind.	Yes	313b E-1
03 32 017	701	Performance of swine fed pesticides and residues in body tissue.	Beltsville, Md.	Yes	701 D-1
03 32 018	701	Pesticide residue accumulation and elimination by swine.	Beltsville, Md.	No	

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Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 32 019	311	Interrelationships of calcium, phosphorus, and zinc retention in swine.	Beltsville, Md.	Yes	701 D-2
03 32 020	311	Effect of nutrition on lines of swine selected for high- and low-backfat thickness.	Beltsville, Md.	Yes	311 E-1
03 32 021	311	Evaluate nutritive quality and safety of improved cottonseed meals and detoxification methods.	Beltsville, Md.	Yes	311 E-2
03 32 022	313a	Selection for combining ability of three lines of swine.	Stillwater, Okla.	Yes	310 E-1h 313a E-1e, 2b,c,d
03 32 023	313a	Inbreeding, linecrossing and selection within and between three breeds of swine.	Brookings, S. D.	No	
03 32 024	313a	Methods of breeding and selection in swine.	Madison, Wisc.	Yes	409 E-3 313a E-2a, b
03 32 025	310	Separation of young and old spermatozoa.	Rehovoth, Israel	Yes	310 E-2
03 32 026	310	Factors acting in long-term storage of sperm <u>in vivo</u> .	Rehovoth, Israel	Yes	310 E-3
03 32 027	313a	Investigations of blood groups in a new racial group of the "Zlotnicka" pig.	Poznan, Poland	Yes	313a E-1d
03 32 028	311	Protein metabolism in monogastric animals connected with their requirements for essential limited amino acids.	Belgrade, Zemun, Yugoslavia	Yes	311 E-3
03 32 029	409	Physiological factors controlling the occurrence of pale, soft and exudative meat in pigs.	Polish Academy of Sciences, Warsaw, Poland	Yes	409 E-4

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				Summary of Progress (Yes-No)	Area & Subheading
03 33		Sheep and Wool*			
03 33 001	313a	Lamb and wool production from crosses among several breeds of sheep.	Beltsville, Md.	Yes	313a D-5 409 D-1
03 33 002	313a	Development of a strain of sheep for lamb and wool production under farm conditions.	Beltsville, Md.	Yes	409 D-1
03 33 003	313a	Systems of breeding for improvement of range sheep.	Dubois, Idaho	Yes	313a D-1,2, 3,4
03 33 004	313a	Traits for use in breeding and selection of range sheep.	Dubois, Idaho	Yes	313a D-1,2
03 33 005	310	Physiology of reproduction of range sheep.	Dubois, Idaho	Yes	310 D-1,2, 3,4,5,6,7
03 33 006	310	Estrus in sheep as related to reproductive performance.	Beltsville, Md.	Yes	310 D-9
03 33 007	313a	Testing of inbred lines of sheep through top crossing.	Dubois, Idaho	Yes	313 D-3,4
03 33 008	313a	Improvement of commercial range sheep through breeding and selection.	Beltsville, Md.	Yes	313a D-8
03 33 009	311	Factors in the utilization of pelleted feeds by sheep.	Beltsville, Md.	Yes	211 A-3 311 D-1a
03 33 010 1	211	Physiology of sheep and other ruminants in relation to metabolic disorders.	Beltsville, Md.	Yes	211 A-1,2
2	211	Physiology of sheep and other ruminants in relation to metabolic disorders.	College Station, Tex.	No	
03 33 011	311	Investigations on the utilization of forage by sheep.	Beltsville, Md.	Yes	311 D-1b 313b D-4,6
03 33 012	313b	Investigations of sheep grazing management on ranges of the Intermountain Region.	Dubois, Idaho	Yes	313b D-3
03 33 013	313a	The response of Targhee sheep to different environments.	Beltsville, Md.	No	
03 33 014	313b	Investigations of the nutrition and management of range sheep.	Dubois, Idaho	Yes	311 D-1d 313b D-1,2
03 33 015	311	Productivity of pastures grazed by beef cattle and sheep alone and in combination.	Beltsville, Md.	Yes	313b D-5
03 33 016	212	Influence of management practices on internal parasitism of lambs.	Beltsville, Md.	Yes	212

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				Summary of Progress (Yes-No)	Area & Subheading
03 33 017	310	Performance of ewes lambing twice yearly.	El Reno, Okla.	Yes	313a D-7
03 33 018	409	Evaluation of wool from farm sheep for breeding, nutrition, and management studies.	Beltsville, Md.	Yes	409 E-4
03 33 019	409	Relationships of fleece traits to measurable characteristics of card sliver, top, and noils from sheep of known genetic origin.	Beltsville, Md.	Yes	409 E-5
03 33 020	701	Effect of insecticides in feed on growth, body stores, and reproduction of sheep.	Beltsville, Md.	Yes	213 B-1
03 33 021	311	Utilization of different kinds of protein feeds by ruminants.	Rehovoth, Israel	Yes	311 D-1e, D-5
03 33 022	211	Carbohydrate and fat economy of lactating sheep in reference to ketosis.	Jerusalem, Israel	Yes	211 A-6, D-6
03 33 023	310	Development of artificial insemination of sheep.	Rehovoth, Israel	Yes	311 D-1c
03 33 024	211	White muscle disease of lambs in Turkey.	Ankara, Turkey	Yes	211 A-7
03 33 025	310	Transmission of ram epididymitis organism and its control by management.	Dubois, Idaho	Yes	211 A-5
03 33 026	310	Pregnancy diagnosis in sheep and goats.	Beltsville, Md.	Yes	310 D-8
03 33 027	313a	Selective mating and breed comparisons of sheep for farm regions.	Beltsville, Md.	Yes	409 D-2,3
03 33 028	310	Development of a strain of sheep capable of reproducing more than once per year and any time of the year.	Beltsville, Md.	No	
03 33 029	311	Nutrition requirements of pregnant and lactating ewes and their lambs.	Ithaca, N. Y.	No	
03 33 030	409	Effect of management and nutrition on wool growth and quality.	Dubois, Idaho	No	
03 33 031	310	Secretion of anterior pituitary hormones and ovulation in small ruminants.	Jablonna, Poland	Yes	310 E

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				Summary of Progress (Yes-No)	Area & Subheading
03 34		Other Animals*			
03 34 001	313a	Genetics of mink and marten with emphasis on mutant characters and pelt quality.	Madison, Wisc.	Yes	313a D-9, 10
03 34 002	313b	Development of a superior strain of blue foxes.	Petersburg, Alaska	Yes	311 D-3g
03 34 003	310	Marten mating systems to increase breeding regularity and prolificacy.	Petersburg, Alaska	Yes	310 D-10
03 34 004 1	310	Effects of hormones and environment on growth and reproduction of mink.	Ithaca, N. Y.	Yes	211 A-8 310 D-11, 12
2	310	Effects of hormones and environment on growth and reproduction of mink.	Madison, Wisc.	No	
03 34 005	213	Effects of DDT on reproductive performance and growth of mink.	Ithaca, N. Y.	Yes	213 B-2
03 34 006 1	311	Development of diets based on ocean and fresh water fish and sea mammals and their products for blue fox, mink and marten.	Ithaca, N. Y.	No	
2	311	Development of diets based on ocean and fresh water fish and sea mammals and their products for blue fox, mink and marten.	Petersburg, Alaska	Yes	311 D-3a,b, c
03 34 007	311	Investigation of the basic nutrient requirements and nutrient utilization by mink.	Ithaca, N. Y.	Yes	311 D-3d, e, f
03 34 008	311	Development of practical diets and feeding practices for mink.	Ithaca, N. Y.	No	
03 34 009	409	Influence of physiological factors on the histogenesis, growth and shedding of animal fibers.	Beltsville, Md.	No	
03 34 010	409	The priming process of fur-bearing animals.	Beltsville, Md.	No	
03 34 011	311	Milk and meat potentialities in Indian goats.	Agra, Uttar Pradesh, India	Yes	311 D-2
03 34 012	313a	Genetic and environmental aspects of Angora goat production.	Ankara, Turkey	No	

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CRIS Unit Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 98		Pioneering Labs *			
03 98 001	310	Biochemistry and physiology of mammary gland growth and development.	Beltsville, Md.	Yes	311 F-1
03 98 002	310	Secretion rate and metabolism of hormones in dairy cattle as related to reproductive function.	Beltsville, Md.	Yes	310 F-1a,b, c, 2, 3
03 98 003	310	Biochemical factors involved in implantation, placental development and gestation.	Beltsville, Md.	No	
03 98 004	310	Estrogen control of biochemistry and growth of female reproductive tissues.	Beltsville, Md.	Yes	310 F-1e
03 98 005	310	Uptake of female sex hormones by receptors in reproductive tissues.	Beltsville, Md.	Yes	310 F-1d
03 98 006	313a	Purification and structure of anti-A agglutinins.	Beltsville, Md.	No	
03 98 007	313a	Cell regulation involving hormones and genes: Chicken erythrocyte antigens.	Beltsville, Md.	No	
03 98 008	313a	Somatic cell variation in pigeons.	Beltsville, Md.	No	
03 98 009	313a	The effect of x-rays on viability genes with special reference to their action in heterozygotes and to the mechanism of heterosis.	Jerusalem, Israel	Yes	313a F-2e
03 98 010	313a	Methods and theories of population genetics.	Lafayette, Ind.	Yes	313a F-1,2e

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CRIS Unit Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work & CRIS Unit Number	RPA No.	Work Project & CRIS Unit Titles	Work Locations During Past Year	CRIS Unit Included In	
				Summary of Progress (Yes-No)	Area & Subheading
03 99		Broadly Based*			
03 99 001	409	Quantitative meat characteristics as affected by growth and maturity.	Beltsville, Md.	Yes	409 A-1
03 99 002	701	Metabolism of diiodosalicylic acid.	Fargo, N. D.	Yes	701 E-3
03 99 003	701	Metabolic fate of pesticides in animals.	Fargo, N. D.	Yes	701 E-2b
03 99 004	701	Gastrointestinal absorption of agricultural chemicals in animals.	Fargo, N. D.	Yes	701 E-4
03 99 005	701	Metabolism of chlorinated hydro- carbon insecticides in livestock.	Fargo, N. D.	Yes	701 E-2a
03 99 006	701	Metabolism of agricultural chemicals by rumen microorganisms.	Fargo, N. D.	No	
03 99 007	701	Metabolic fate of estrus-control chemicals in animals.	Fargo, N. D.	No	
03 99 008	701	Metabolite formation in metabolism of triazine herbicides by the animal.	Fargo, N. D.	Yes	701 E-1,4

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